TATA McGRAW HILL'S WE SERIES

INDIAN AND WORLD GEOGRAPHY

Physical, Social, Economic Geography of India and the World

FOR CIVIL SERVICES PRELIMINARY EXAMINATION

PAPER – I

MAJID HUSAIN

TATA McGRAW-HILL'S WINNING WE EDGE SERIES

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PAPER - I

Majid Husain
Prof. (Retd), Jamia Millia Islamia
(Central University)
New Delhi

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CONTENTS

Preface v

PART - I
WORLD GEOGRAPHY

Chapter 1: The Universe and the Solar System **1.3 – 1.17**

The Universe *1.3*

The Solar System *1.7*

References 1.17

Chapter 2: Geomorphology **2.1 – 2.51**

Earth's Four Spheres *2.1*

Geomorphology *2.2*

The Interior of the Earth *2.2*

Rocks *2.5*

Continental Drift *2.9*

Plate Tectonics *2.11*

Continental Relief *2.13*

Volcano *2.15*

Earthquakes *2.19*

Denudation *2.22*

References 2.50

Chapter 3: Climatology **3.1 – 3.55**

Atmosphere *3.1*

Atmospheric Pressure *3.11*

Atmospheric Circulation *3.11*

Horizontal Distribution of Air Pressure *3.13*

Meridional Circulation *3.17*

Moisture in the Atmosphere *3.35*

References 3.54

Copyrighted material

Chapter 4: Oceanography 4.1 – 4.16

Oceans *4.1*

References 4.16

Chapter 5: Biogeography 5.1 – 5.8

Biosphere (Ecosphere) *5.1*

Ecosystems of the Earth *5.3*

Soil System *5.8*

References 5.12

Chapter 6: Facts About The World/ Continents/Countries 6.1 – 6.83

Age and Dimensions of Earth *6.1*

Africa *6.2*

Antarctica *6.5*

Asia *6.6*

Australia and Oceania *6.8*

Europe *6.9*

North America *6.12*

South America *6.15*

Ocean Trenches *6.32*

Highest Dams of the World *6.41*

Facts about the Countries *6.57*

References 6.83

Chapter 7: World Economic Geography 7.1 – 7.12

Resource: Concept and Types *7.1*

Energy Resources *7.1*

Mineral Resources *7.12*

References 7.42

Chapter 8: Agriculture 8.1 – 8.35

Feeding the World *8.1*

Agricultural Regions of the World *8.1*

Fishing and Forestry *8.29*

References 8.35

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Chapter 9: Human Geography **9.1 – 9.31**

First People (Major Tribes of the World) *9.1*

Indigenous People of Africa *9.3*

Indigenous People of Asia *9.8*

Indigenous People of Australia and New Zealand *9.12*

Indigenous People of Eurasia *9.13*

Indigenous People of North America *9.13*

Indigenous People of South America *9.14*

Population Patterns of the World *9.15*

International Trade Organisation *9.24*

References 9.31

PART - II

INDIAN GEOGRAPHY

Chapter 10: India–Physical Setting **10.1 – 10.80**

Size and Location *10.3*

Drainage of India *10.10*

Major Passes of India *10.18*

Monsoon *10.25*

Natural Vegetation *10.25*

Soils of India *10.34*

Water Resources of India *10.38*

Natural Hazards *10.45*

Power Resources *10.51*

Mineral Resources *10.63*

Cotton Textile Industry *10.66*

Iron and Steel Industry *10.72*

National Highways *10.72*

International Trade *10.79*

References 10.80

Copyrighted material

Chapter 11: Population 11.1 – 11.32

Growth of Population *11.1*

Density of Population *11.2*

Sex Ratio *11.3*

Literacy Rate *11.4*

Religious Composition *11.10*

Major Scheduled Tribes of India *11.12*

Scheduled Castes *11.19*

Human Development *11.24*

References 11.32

Chapter 12: Indian States 12.1 – 12.53

References 12.53

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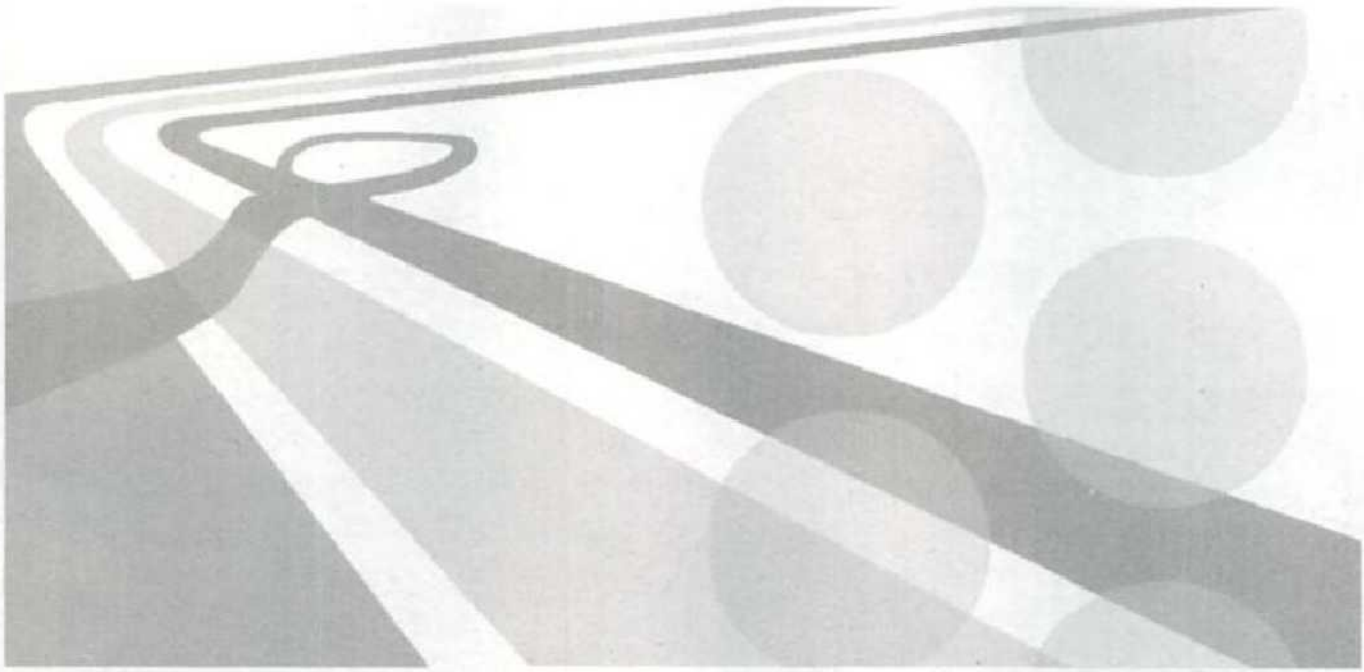

PART – I

WORLD GEOGRAPHY

- The Universe and the Solar System
- Geomorphology
- Climatology
- Oceanography
- Biogeography
- Facts about the World/Continents/ Countries
- World Economic Geography
- Agriculture
- Human Geography

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Chapter One

The Universe and the Solar System

Chapter Concepts

- The Universe
- The Solar System

The Universe

The universe is incomprehensively large in size and dimension. It contains everything that exists, from the tiniest subatomic particles to galactic super-clusters (the largest structure known). Nobody knows how big the universe is, but astronomers estimate that it contains about 100 billion galaxies, each comprising an average of 100 billion of stars.

Expanding Universe

The evolutionary theory of the universe conforms to the principle that the distribution of galaxies is uniform in all directions throughout the space. Under this concept, to an observer from any galaxy, the average composition of the universe would appear the same.

Galaxies

A galaxy is a huge mass of stars, nebulae, and inter-stellar material. The smallest galaxies contain about 100,000 stars, while the largest contains up to 3000 billion stars.

Galaxies are the major building blocks of the universe. A galaxy is a giant family of billions of stars, and is held together by its own gravitational field. The universe is organised into galaxies of stars together with gas and dust.

From the billions of galaxies, two basic types have been identified:

(i) Regular galaxies, and (ii) Irregular galaxies. The regular galaxies **(Fig. 1.1)** may be disc-shaped, elliptical and they generally have new stars. The stars of the irregular galaxies are very old **(Fig. 1.2)**.

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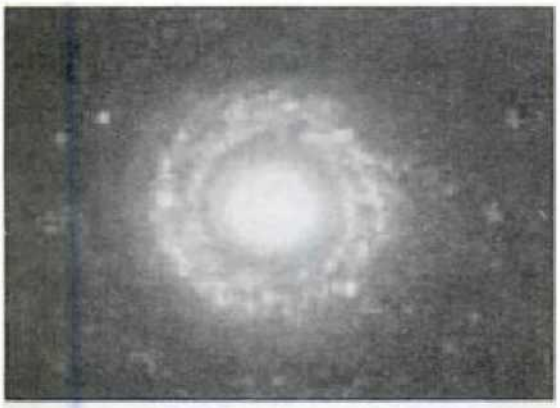

Fig. 1.1(A) – Disc - Shaped

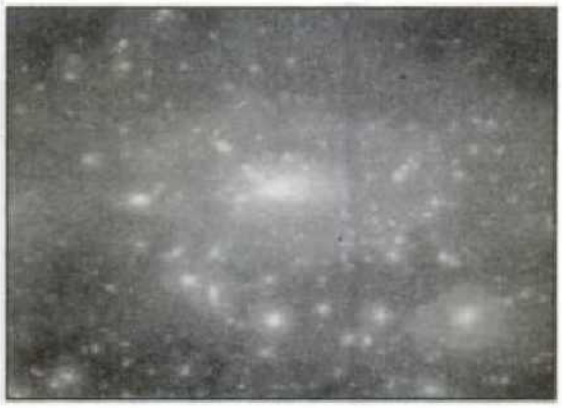

Fig. 1.1(C) – Elliptical Galaxy

Fig. 1.1(B) – Disc - Shaped Andromeda

Fig. 1.1(D) – Elliptical

Fig. 1.1 (A,B,C,D) – Regular galaxies

(i) Regular Galaxies

The regular galaxies may be of either spiral or elliptical in shape.

(a) Spiral Galaxies

The Milky Way and the Great Galaxy in Andromeda are examples of large spiral galaxies—disc-shaped with greater concentration of stars near their centres **(Fig. 1.2)**. The spiral galaxies have curved spiral arms. About 25% of all galaxies have curved spiral arms. Spiral galaxies are well supplied with the interstellar gas in which new bright, young stars form. As the rotating spiral pattern sweeps around the galaxy, it encompasses gas and dust, triggering the formation of bright young stars in its arms.

(b) Elliptical Galaxies

The most abundant are probably the elliptical galaxies. These are generally smaller than the spiral galaxies. They are generally symmetrical or spheroidal shape with no obvious structure. Most of their member stars are very old and no new star forming in them. Some of them are so small that the term *'dwarf'* has been applied. The largest known elliptical galaxy is 200,000 light years in diameter. The biggest and the brightest galaxies in the universe are elliptical with masses of 10^{13} times that of our Sun. About two-thirds of all the galaxies are elliptical.

(ii) Irregular Galaxies

The irregular galaxies comprise about one-tenth of all galaxies and come in many sub-

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classes. The stars of the irregular galaxies are generally very old. Some of them have a mixture of the old and new stars. The *Milky Way* and other spiral galaxies consist of populations of old stars in the centre, and the youngest stars located in the arms.

Fig. 1.2 (A)

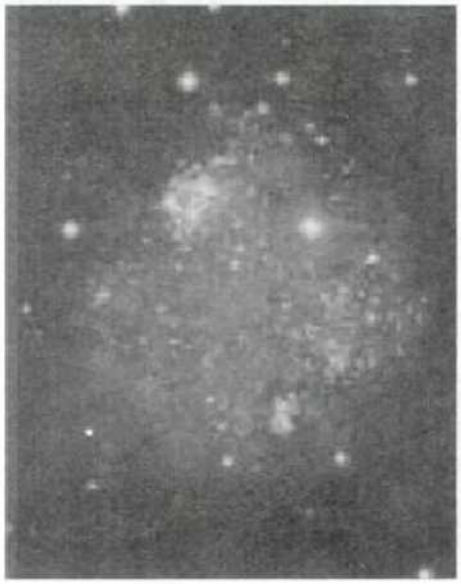

Fig. 1.2 (B)

Fig. 1.2 (C)

Fig. 1.2 (D)

Fig. 1.2 – Irregular galaxies

Our Galaxy *(Milky Way)*

Our galaxy has the shape of a flat disc with a central bulge. Its diameter is about a hundred thousand light years. In the nucleus the thickness reaches ten thousand light years, whereas in the disc it is five hundred to two thousand light years thick. It consists of stars, gas and dust; superimposed on the general distribution of the star in the pair of spiral arms. We do not know exactly how far the Sun is from the centre, but it is conventionally taken to be 33,000 light years away. Thus our solar system is relatively far from the galactic centre. Our galaxy is vast, about 100,000 light years across (a light year is about 9460 billion kilometers or 9.4607×10^{12} km in comparison the solar system seems small of about 12 light years across

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(about 13 billion kilometers). The entire galaxy is rotating in the space, although the inner stars travel faster than those further out. The Sun which is about one-third out from the centre, completes one lap of galaxy in about every 220 million years (**Fig.1.3**).

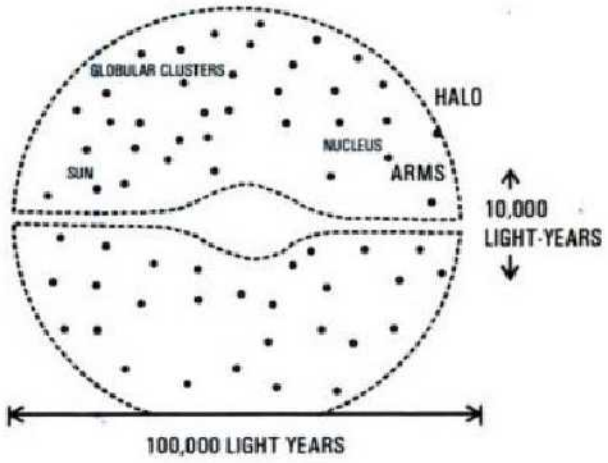

Fig. 1.3 – Our galaxy – The Milky Way

Nebulae

A nebula is a cloud of dust and gas inside a galaxy **(Fig.1.4).** Nebulae become visible if the gas glows or if the cloud reflects straight or obscures light from distant objects. The processes of evolution of stars and star-systems from a nebula have been shown in **Fig. 1.5**.

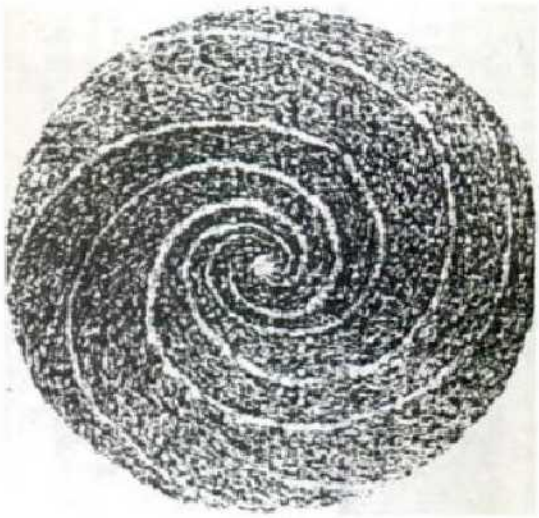

Fig. 1.4 – Nebulae

Dwarfs

White dwarfs are extremely small stars with densities greater than that of any known terrestrial material. It is believed that white dwarfs were once normal sized stars whose internal heat energy was able to keep these gaseous masses from shrinking under their own gravitational force. Eventually, however, these stars depleted their nuclear fuel and collapsed to planetary size. Although some white dwarfs are not larger than the Earth, they are nearly as massive as the Sun. Thus, their densities may be a million times that of

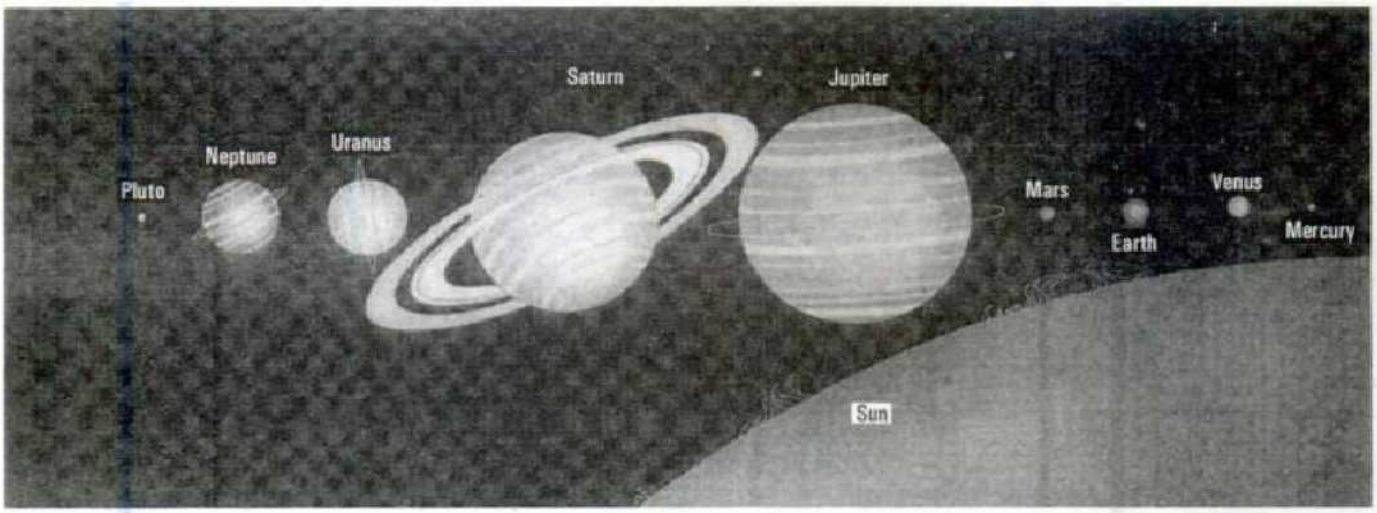

Fig. 1.5 – A size comparison of planets in our Solar System. The size of each planet and the Sun is approximately to scale.

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water. A spoonful of such matter would weigh several tons. Great densities are only possible when electrons are displaced from their regular shells and pushed closer to the nucleus, allowing atoms to take up less space. The matter in this state is called '***degenerate matter***'.

Once a star has contracted into a white dwarf, it is without a source of energy and can only become cooler and dimmer. Although none has been sighted, the terminal stage of white dwarf must be small, cold, non-luminous body called a '***black dwarf***'.

Black Holes (Neutron Stars)

The smaller white dwarfs are the most massive, and the larger one are the least massive. The reason for this is that a more massive star, because of its greater gravitational force, is able to squeeze itself into a smaller, more densely packed object than a less massive star. Thus, the smaller white dwarfs were produced from the collapse of larger and more massive stars. If the earth were to collapse to the density of a white dwarf (neutron star), it would have a diameter equivalent to the length of a football field.

The Solar System

The family of the 'Sun' is known as the solar system. Eight major planets, one dwarf planet (Pluto), satellites and countless minor planets (asteroids), meteors, and comets orbit the Sun to form the solar system. The Sun, our motherly and nearest star, creates energy from nuclear reactions deep within the interior, providing all the light and heat that make life possible on the Earth. The size, comparison and relative distance of planets in our solar system has been shown in **Fig.1.5**.

Origin of Solar System

The solar system was probably formed by the gravitational collapse of a huge cloud of gas and dust. The reason for differences in planetary composition appears to be related to distance from the Sun. Bodies close to the Sun (the terrestrial planets) were formed from rocks and metals that crystallized at high temperature, while the outer planets were formed from elements that form solids (condense) at low temperatures.

Most scientists believe that the universe began about 15 billion years ago in what has become known as the ***Big Bang***. This gigantic explosion caused matter to expand to form billions of swirling galaxies and over the time, the stars and their planets. It is generally believed that our solar system was spawned in a cold, diffuse cloud of gas and dust, deep within the spiral arm of the Milky Way Galaxy. The huge cloud was made up largely of two lightest elements, hydrogen and helium along with traces of other elements including oxygen, silicon, and iron. The cloud rotated slowly about a central concentration of mass and contained a system complicated eddies. Under the force of gravity, the giant cloud began to collapse and assume the shape of a rotating disc, with an increasingly hot and dense mass at the centre.

Sun

Diameter: 1,392,000 km (864,948 miles)
Mass: 1990 million, million, million, million tons
The Sun was formed when a swirling cloud of dust and gas contracted, pulling the matter into its centre. When the temperature at the centre rose to 1,000,000°C, nuclear fusion – the fusing of hydrogen into helium, creating energy– occurred, releasing a constant stream of heat and light.

Photosphere

The photosphere is the bright outer layer of the Sun that emits most of the radiation, particularly visible light. It consists of a zone of burning gases 300 km thick. The photosphere is an extremely uneven surface. The effective temperature on the outer side of the photosphere is 6000°K (11,000°F).

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Chromosphere

Just above the photosphere is the chromosphere. It is relatively a thin layer of burning gases.

Sunspot

A dark patch on the surface of the Sun is known as sunspot. Sunspots appear as dark areas because they are about 1500° cooler than the surrounding chromospheres. The individual sunspot has a lifetime ranging from a few days to a few months. Each spot has a black centre or umbra, and a lighter region or penumbra, surrounding it. The number of visible sunspots fluctuates in an eleven year cycle. It has been suggested that the Sun is 1% cooler when it has no spot, and that this variation in solar radiation might affect the climates of the Earth.

Planet

A celestial body moving in an elliptical orbit round a star, the Earth is known as planet. Planets are generally divided into :
(i)the Inner Planets (Mercury, Venus, Earth and Mars), and (ii) the Outer Planets (Jupiter, Saturn, Uranus, Neptune, and Pluto-dwarf planet).

Inner Planets

Mercury (*God of Commerce and Skill*)
Diameter: 4,878 km (3,031 miles)
Mass: 330 million, million, million tons
Temperature: -173° to 427°C
Distance from the Sun: 58 million km (36 million miles)
Length of day: 58.65 earth days
Length of year: 87.97 earth days
Surface gravity: 1kg = 0.38 kg

Mercury is similar to the Moon with a surface dominated by craters and a younger area of dark plains presumably made from floods of lava. Most of the Mercury's surface is nearly saturated with craters whose range of sizes is similar to that of Moon's craters.

Venus (The Veiled Planet, Goddess of Beauty)

Diameter: 12,102 km (7,520 miles)
Mass: 4,870 million, million, million tons
Temperature: 457°C (extremes not available)
Distance from the Sun: 108 million km (67 million miles)
Length of day: 243.01 earth days
Length of year: 224.7 earth days
Surface gravity: 1kg = 0.88 kg
Venus is often considered to be the Earth's twin, but the two planets are not identical. Venus has high plateaus, folded mountain belts, numerous volcanoes, and relatively smooth volcanic plains. The surface of Venus is totally obscured by a thick atmosphere composed mostly of carbon dioxide, with clouds of sulfuric acid. It contains volcanic plains, mountain belts, volcanoes and two high *'continents'* that rise several kilometers above vast rolling low lands which shows that Venus has a surface similar, in some ways, to the surface of the Earth with its continents and ocean basins.

Earth

Diameter: 12,756 km (7,926 miles)
Mass: 5,976 million, million, million tons
Temperature: -80° to 58°C
Distance from the Sun: 150 million km (93 million miles)
Length of day: 23.92 hours
Length of year: 365.25 earth days
Surface gravity: 1 kg = 1 kg

The Earth is shaped like a ball, but it is not perfectly round. The force of the Earth's rotation makes the world bulge very slightly at the equator and go a little flat at the North and the South poles. So the Earth is actually a flattened sphere, or a *'geoid'*.

The Earth is unique among the terrestrial planets (Mercury, Venus, Earth, and Mars) because of its size and distance from the Sun. The Earth is unique in the solar system in that it supports life: its size, gravitational pull and

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distance from the Sun have all created the optimum conditions for the evolution of life. It is large enough to develop and retain an atmosphere and a hydrosphere. Temperature ranges on the Earth are such that water can exist on its surface as liquid, solid, and gas. Water, more than anything else, makes the planet Earth unique. The Earth is a delicate ball wrapped in filmy white clouds. The blue water and swirling patterns of clouds that dominate the scene underline the importance of water in the Earth's system.

The Earth's Atmosphere

During the early stages of the Earth's formation, ash, lava, carbon and water vapour were discharged onto the surface of the planet by constant volcanic eruptions. The water formed the oceans, while carbon dioxide entered the atmosphere or was dissolved in the oceans. Clouds, formed of water droplets, reflected some of the Sun's radiation back into space. The Earth's temperature stabilised and early life forms began to merge, converting carbon dioxide into life-giving oxygen.

The Earth's oceans and seas cover more than 367 million sq km, i.e. twice the surface of Mars and nine times the surface of the Moon.

The Pacific Ocean contains the deepest places on the Earth's surface–the ocean trenches. The very deepest is the Challenger Deep in the Mariana Trench which plunges 11022 m into the Earth's crust. If Mount Everest, the highest point on land at 8,848m was dropped into the trench, its peak would not even reach the surface of the Pacific.

Mars (Red Planet, God of War)

Diameter: 6,786 km (4,217 miles)
Mass: 642 million, million, million tons
Temperature: -137° to 37°C
Distance from the Sun: 228 million km (142 million miles)
Length of day: 24.623 hours
Length of year: 188 earth years
Surface gravity: 1 kg = 0.38 kg

Mars is smaller than the Earth and Venus, but has many fascinating geological features, indicating that its surface has been dynamic. Almost every geologic feature is gigantic. Three huge volcanoes, one more than 28 km high exists at Mars. An enormous canyon extends across the entire hemisphere, a distance roughly equal to that from New York to San Francisco. Mars is a planet of fascinating geologic features. Almost everything is gigantic including the landscape and eroding deep channels. Wind action is also an important process: volcanoes, canyons, and landslides. There is evidence not only of stream action, but of catastrophic flooding in which sheets of water, possibly 300 m deep, surged over the landscape, eroding deep channels. Wind action is also an important process on Mars. In addition polar regions are covered with alternating layers of ice and wind blown sediment.

Outer Planets

Outer Planets are Jupiter, Saturn, Uranus, Neptune and the dwarf planet – Pluto. Planetary bodies in the outer solar system were formed mostly of the lighter elements: hydrogen, helium, and oxygen. Hence, the satellites of the giant planets are composed mostly of ice, not of rock, like the inner planets.

Jupiter (Giant Planet, Ruler of Gods)

Diameter: 142.984 km (88,846 miles)
Mass:1,900,000 million, million, million tons
Temperature: -153°C (extremes not available)
Distance from the Sun: 778 million km (483 million miles)
Length of day: 9.84 hours
Length of year: 11.86 earth years
Surface gravity: 1 kg = 2.53 kg

It is composed mostly of gas and liquid swirling in complex patterns. Jupiter has no solid surface and hence no record of a geologic history. Its moons are, however, solid planetary bodies that contain geologic wonders. Jupiter's four large moons (Io, Europa, Ganymede, and Callisto), called the Galilean satellites because they were discovered by Galileo in 1610, have

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composition dramatically different from those of the rocky inner planets. Three of these moons have surfaces composed mostly of water ice. Each of the Jupiter's moons shows a diverse landscape resulting from impact, volcanism, and surface fracture. Jupiter has a volume of 1300 times greater than that of the Earth.

Saturn (Ringed Planet, God of Agriculture)

Diameter: 120,660 km (74,974 miles)
Mass: 570, million, million, million tons
Temperature: -185°C (extremes not available)
Distance from the Sun: 1,427 million km (887 million miles)
Length of day: 10.23 hours
Length of year: 29.46 earth years
Surface gravity: 1 kg = 1.07 kg

Saturn is similar to Jupiter in many ways. It is a gigantic ball of gas, mostly of hydrogen, and helium, and is the centre of a miniature planetary system with an elaborate family of satellites. Its atmosphere is marked by dark bands alternating with higher lighter zones. Saturn's rings for long have been considered as its most dramatic feature. The rings are probably made up of billions of particles of ice and ice-covered rocks, ranging from a few micrometers to a metre or more in diameter. Each particle moves in its independent orbit around Saturn, producing an extra-ordinarily complex ring structure.

Uranus (The Green Planet, God of Heavens)

Diameter: 51,118 km (31,763 miles)
Mass: 86,800 million, million, million tons
Temperature: -214°C (extremes not available)
Distance from the Sun: 2,870 million km (1,783 million miles)
Length of day: 17.9 hours
Length of year: 84.01 earth years
Surface gravity: 1 kg = 0.92 kg

Like Jupiter and Saturn, it has no solid surface, but is enveloped by a thick atmosphere of hydrogen and helium. In contrast to all other planets in the solar system, it is tipped and spun on its sides, that is its axis of rotation lies nearly the plane of its orbit. Thus, it rolls, like a ball, as it moves on its orbital path around the Sun, whereas other planets spin like tops. Uranus has five major moons. Each moon occupies a nearly circular orbit, lying in the plane of Uranus' equator.

Neptune (A Twin, God of Sea)

Diameter: 49,528 km (30,775 miles)
Mass: 102,000 million, million, million tons
Temperature: -225° C (extremes not available)
Distance from the Sun: 4,497 million km (2,794 million miles)
Length of day: 19.2 hours
Length of year: 164.79 earth years
Surface gravity: 1 kg = 1.18 kg

Uranus and Neptune are called the twins of the outer solar system. Surrounded by thick atmosphere of hydrogen, helium and methane. It has about a dozen moons, out of which Triton is the largest.

Pluto (A Dwarf Planet–God of Death)

Diameter: 2300 km (1428 miles)
Mass: 13 million, million, million tons
Temperature: -236°C (extremes not available)
Distance from the Sun: 5,900 million km (3,666 million miles)
Length of day: 6.39 hours
Length of year: 248.54 earth years
Surface gravity: 1 kg = 0.30 kg

Asteroids

Millions of objects, remnants of planetary formation, circle the Sun in a zone lying between Mars and Jupiter. They are known as asteroids. Fragments of asteroids break off to form meteoroids, which can reach the Earth's surface. Comets, composed of ice and dust, originated outside our solar system. Their elliptical orbit brings them close to the Sun and into the inner Solar System.

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Table 1.1: *Facts about the Planets*

Planet	*Mean distance from Sun (Million of km)*	*Period of Revolution*	*Inclination to Ecliptic*	*Orbital Velocity (Km/s)*
Mercury	58	88 days	7°00′	47.9
Venus	108	225 days	3°24′	35.0
Earth	150	365.25 days	23°50′	29.8
Mars	228	687 days	1°51′	24.1
Jupiter	778	12 years	1°19′	13.1
Saturn	1427	29.5 years	2°30′	9.6
Uranus	2869	84 years	0°46′	6.8
Neptune	4498	165 years	1°46′	5.4
Pluto	5900	248 years	17°12′	4.7

Source: Tarbuck and Lutgens (1976, p.408).

Table 1.2: *Planets and their Satellites*

Planet	*No. of Known planets*	*Main Satellites*
Mercury	-	-
Venus	-	-
Earth	1	Moon
Mars	2	Deimos, Phobos
Jupiter	65	Ganymede, Callistro, Io, Europa
Saturn	31	Titan, Teythes, Mimas, Rhea, Enceladus, Dione
Uranus	27	Miranda, Titania, Oberon, Ariel, Umbriel
Neptune	13	Triton, Nereid
Pluto	1	Charon

Comets

Comets are among the most spectacular and unpredictable bodies in the solar system. They have been compared with large, dirty snowballs, since they are made of frozen gases (water, ammonia, methane and carbon dioxide) which hold together small pieces of rocky and metallic minerals **(Fig. 1.6)**. Many comets travel along very elongated orbits that carry them beyond the Pluto. On their return, the comets are visible only after they have moved within the orbit of Saturn. One of the larger comets is the Halley's Comet. The orbit of Halley's Comet brings it close to the Earth every 76 years. It last visited in 1986.

Meteoroids

Meteor is a body of matter travelling at a great speed through space which becomes luminous when enters into the atmosphere (ionosphere) at about 200 km above the Earth's surface, because it is heated by friction. Generally, this latter process dissipates the material into meteoric dust. A meteor is popularly termed a *'shooting star' or 'falling star'*.

Meteorite

Any particle of solid matter that has fallen to the Earth, the Moon, or another planet from the space. It is composed of various proportions

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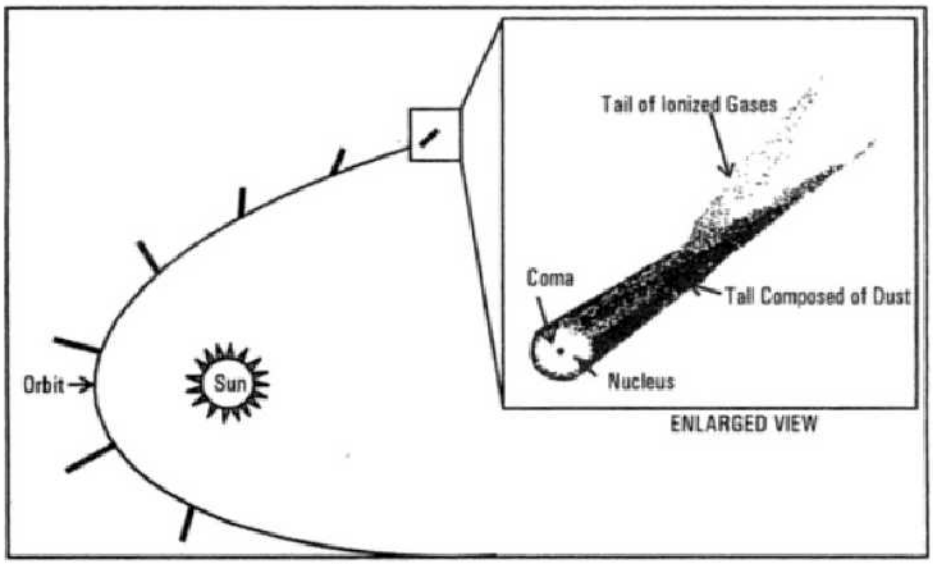

Fig. 1.6: Orientation of a comet's tail as it orbits the Sun

of a nickel-iron alloy (typically about 10% nickel and about 90% iron) and silicate minerals.

Largest Meteor Crater: A meteor crater in Arizona (USA) is 4,200 ft (1,300 m) deep is the largest meteor crater in the world. It was formed over 10,000 years ago.

Seasons

The axial tilt of the Earth of 23.5 degrees as it moves around the Sun causes seasonal changes (Fig 1.7). When in June the Northern Hemisphere tilts towards the Sun, it gets maximum heat while the Southern Hemisphere gets little heat. It is thus summer in the Northern Hemisphere and winter in the Southern Hemisphere. Six months later, in December, the situation is reversed as the Earth travels halfway around the Sun and its Northern Hemisphere is tilted away from the Sun.

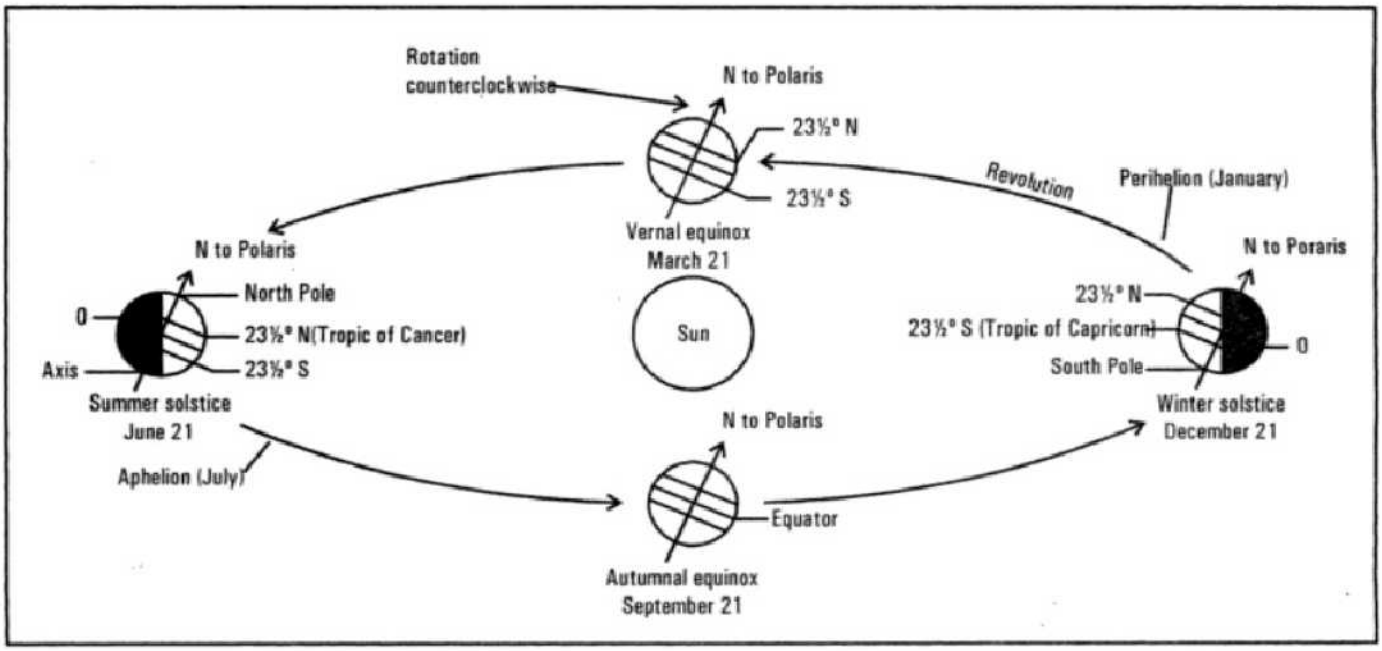

Fig. 1.7 – Earth–Sun relationship

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***Table 1.3**: Five Reasons for Seasons*

Factor	Description
Revolution	Orbit around the Sun; requires 365.25 days to complete at 107,280 kmph (66,660 mph).
Rotation	Earth turning on its axis; takes approximately 24 hours to complete at 1,675 kmph at the equator (1,041 mph)
Tilt	Axis of the Earth is aligned at 23.5° angle from a perpendicular to the plane of the ecliptic (the plane of the Earth's orbit).
Axis	Remains in a fixed alignment of axial parallelism, with Polaris directly overhead at the North Pole throughout the year.
Sphericity	Appears as an oblate spheroid to the Sun's parallel rays; the geoid.

Source: Christopherson, R.W., *1995, **Elemental Geosystem- A Foundation in Physical Geography,*** Prentice Hall, p. 48.

On June 21, the Sun is directly overhead the Tropic of Cancer (23.5° degrees North) and it is mid-summer in the Northern Hemisphere. Mid-summer in the Southern Hemisphere occurs on 23rd December when the Sun is directly overhead the Tropic of Capricorn (23.5° degrees South).

***Table 1.4**: Annual March of the Seasons*

Approximate Date	*Northern Hemisphere Name*	*Location of the Sub-polar Point*
December 21-22	Winter solstice (December solstice)	23.5° S latitude (Tropic of Capricorn)
March 20-21	Vernal equinox (March equinox)	0° (equator)
June 20-21	Summer solstice (June solstice)	23.5o N latitude (Tropic of Cancer)
September 22-23	Autumnal equinox (September equinox)	0° (equator)

Source: Christopherson, R.W., 1995, ***Elemental Geosystems - A Foundation in Physical Geography,*** Prentice Hall, p.51.

The Moon

With the development of space programme, the Moon has become one of the best understood planetary bodies in the solar system. The Moon is the natural satellite of the Earth, with a diameter of 3,470 km. The Moon is pock-marked with billions of craters, which range in size from microscopic pits on the surface of rock specimens to huge circular basins of hundreds of kilometers in diameter.

The Moon rotates more slowly than the Earth and takes a little over 27 days to rotate once. Since it takes about the same time to revolve around the Earth, it always presents the same face or hemisphere to the Earth. The interval between one Full Moon and the next is 29.5 days. The Moon seems to have different shapes at different times of the month because of its changing position in relation to the Earth. The different shapes are known as the phases of the Moon **(Fig. 1.8)**.

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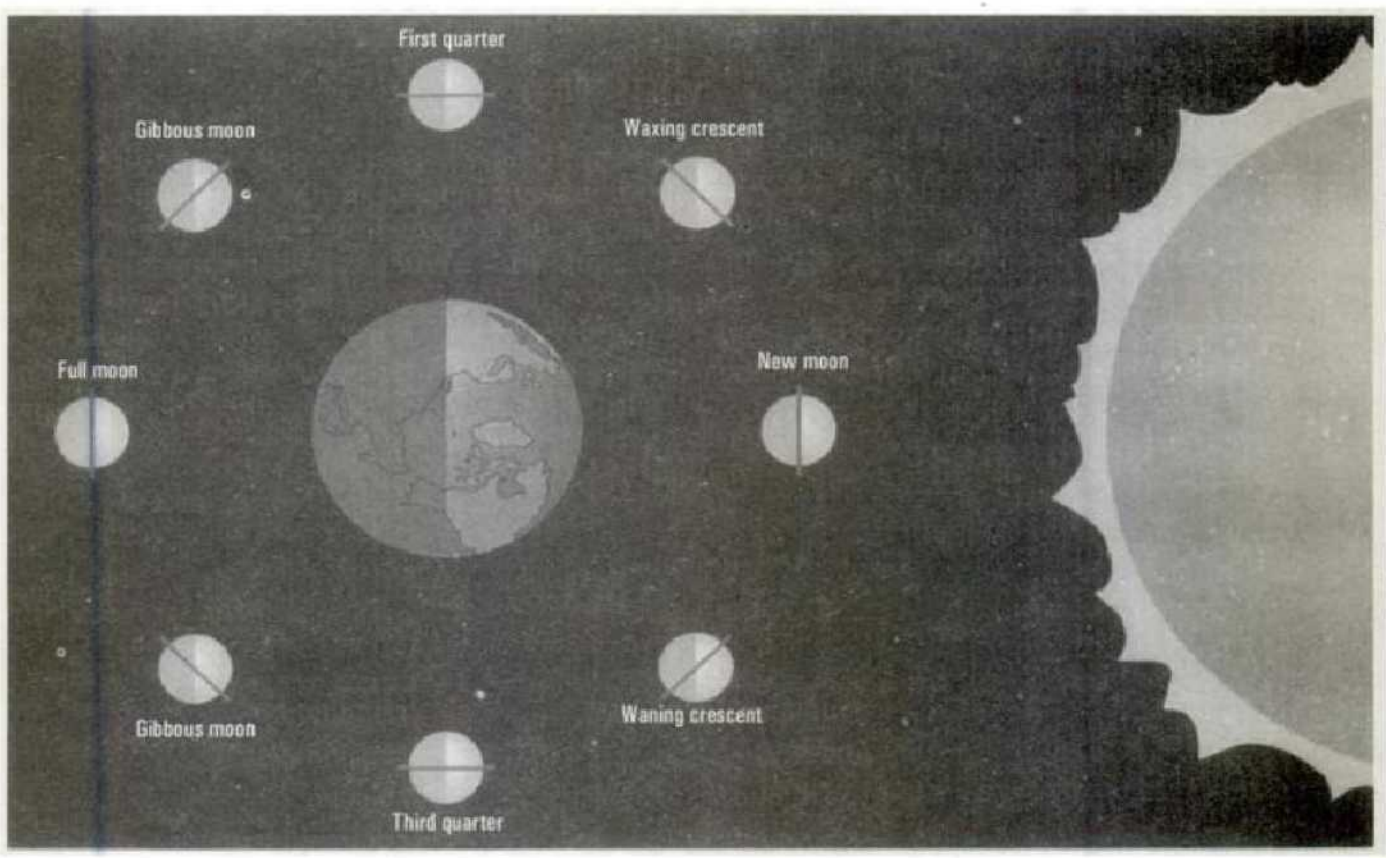

Fig. 1.8 – Phases of the Moon
(After: Conte, Thompson, Moses, *Earth Science*, 1997, Mc Graw Hill Higher Education, p.34)

International Date Line

Any place just west of 180° is twelve hours ahead of Greenwich Mean Time; point just east of it are twelve hours behind. To reconcile these facts, an imaginary line – the International Date Line – has been established. The line follows 180° longitude except where it crosses land so there are some departures from the meridian. As the traveler moves from east to west over the International Date Line he or she 'skips' a day; the date is put forward one day. The traveler moving in an opposite direction keeps gaining time, so that a day must be repeated in order to reconcile the gains; thus, the date is put back one day. The International Date Line and the Standard Time Zone have been shown in **Fig. 1.9**.

Coordinated Universal Time

Greenwich Mean Time was replaced by a universal time system in 1928, and this system was expanded in 1964 when ***Coordinated Universal Time (UTC)*** was instituted. Today, UTC is the reference for official time in all countries. Although the Prime Meridian still runs through Greenwich, UTC is based on an average time calculations collected in Paris broadcast worldwide.

Each time zone theoretically covers 7.5° on either side of a controlling meridian and represents one hour **(Fig. 1.9)**. However, as you can see **(Fig. 1.9)** time zone boundaries are adjusted to keep certain areas together in the same time zone – see China, for example.

Daylight Saving Time

In many countries, time is set ahead one hour in the spring and set back in the autumn – a practice known as *Daylight Saving Time*. The idea of extended daytime in the evening was first proposed by Benjamin Franklin, although not until World War I, did Great Britain, Australia, Germany, Canada and the United States adopt the practice.

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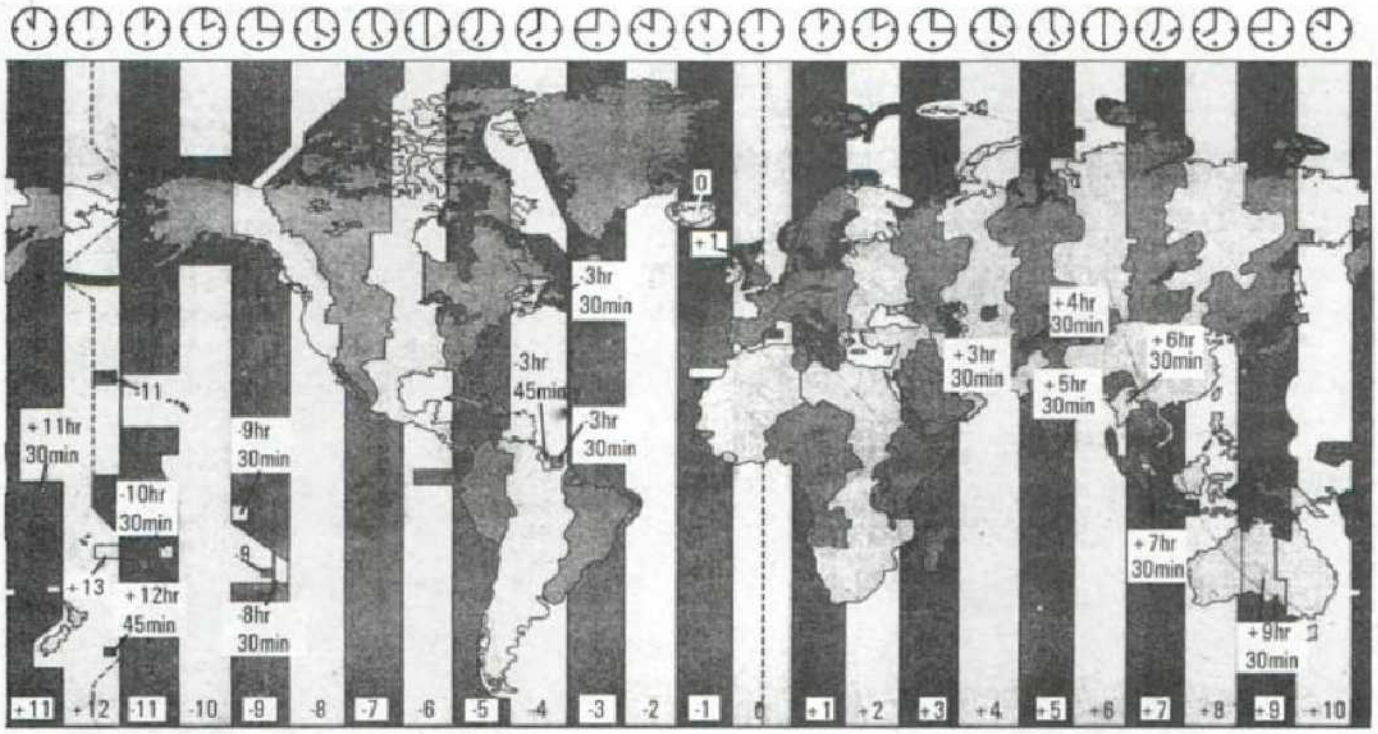

Fig. 1.9 – Standard time zones of the world
(After: *Earth Science* – Mc Graw Hill Higher Education, 1997, p.35)

Clocks in the United States were left advanced an hour from 1942 to 1945 during World War II, producing an added benefit of energy savings (one less hour of artificial light needed), and again during 1974-1975.

Daylight saving time was increased in length in the United States and Canada in 1986. Time is set ahead on the first Sunday in April and set back on the last Sunday in October – only Hawaii, Arizona, portions of Indiana and Saskatchewan exempt themselves. In Europe the last Sunday in March and September generally are used to begin and end Daylight Saving Time.

Great Circles and Small Circles

Great circles and small circles are important concepts that help summarise latitude and longitude. A *great circle* is any circle of Earth's circumference whose centre coincides with the centre of the Earth. An infinite number of great circles can be drawn on the Earth. Every meridian in one-half of a great circle that passes through the poles. On flat maps, airlines and shipping routes appear to arch their way across oceans and landmasses. These are great circle routes, the shortest distance between two points on the Earth. Only one parallel is a great circle – the equatorial parallel. All other parallels diminish in length toward the poles and, along with any other non-great circle that one might draw, constitute small circles – circles whose centres do not coincide with the Earth's centre **(Fig. 1.10)**.

The Northern and Southern Hemispheres

The equator is an imaginary line drawn around the middle of the Earth, where its circumference is the greatest. If we cut the Earth along the equator, the Earth separates into two hemispheres, the northern and the southern hemispheres. Most of the Earth's land is in the Northern Hemisphere. Europe, and North America are the only continents which lie entirely in the Northern Hemisphere. Australia and Antarctica are the only continents that lie in the Southern Hemisphere **(Fig. 1.11)**.

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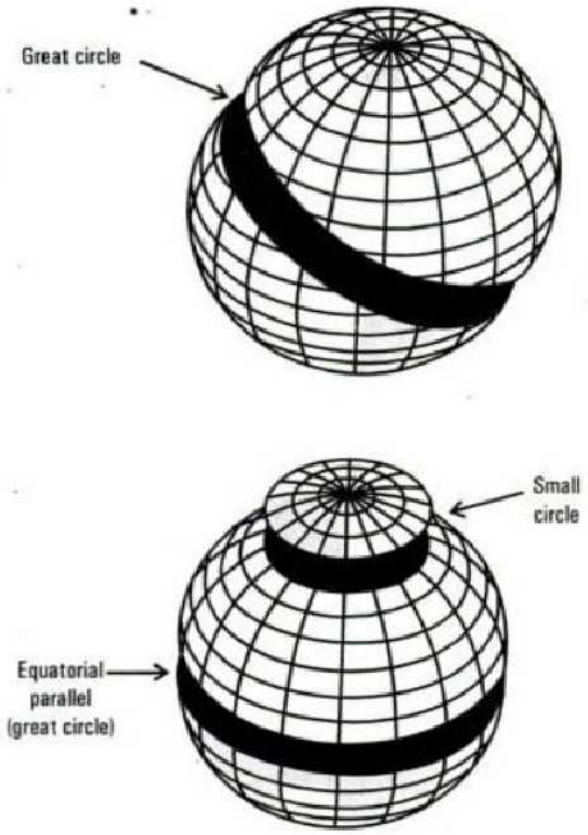

Fig. 1.10 – Great circles and small circles on Earth

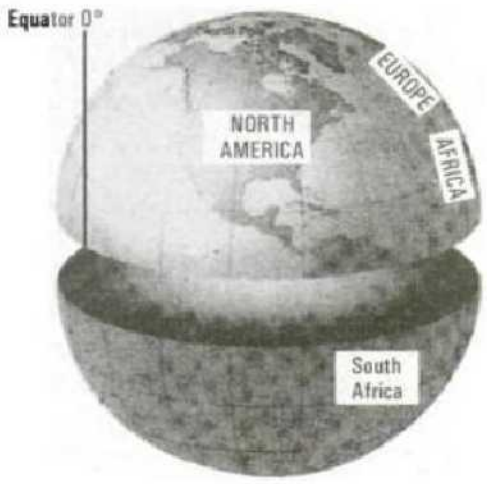

Fig. 1.11 – The southern hemisphere contains three of the Earth's four great oceans — the Pacific, Indian and Arctic oceans

The Eastern and Western Hemispheres

The Earth can also be divided along two other imaginary lines – the Prime Meridian (0°) and 180° – which run opposite each other between the North and South poles. This creates the Eastern and the Western Hemispheres. The continents in the Eastern Hemispheres are traditionally called the *Old World*, while those in the Western Hemisphere – the Americas – were named the New World by the Europeans who explored them in the 15th century **(Fig. 1.12)**.

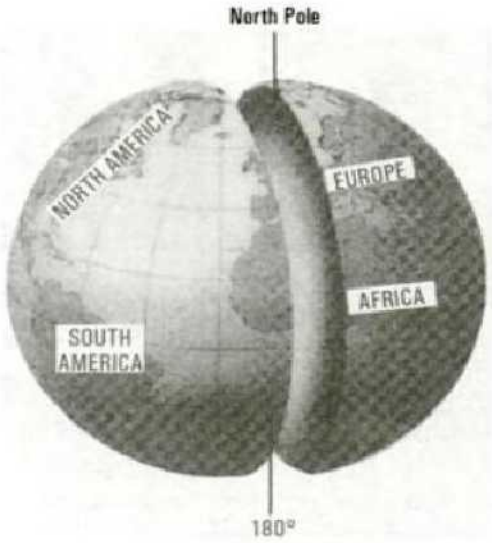

Fig. 1.12 – The Eastern and Western hemispheres

The Land Hemisphere

The land hemisphere is dominated by the continents of Asia, Africa and Europe. The area of the land hemisphere is however, taken up by the waters of the Pacific, Atlantic and Indian oceans.

The Water Hemisphere

The Pacific Ocean is so enormous, it stretches across a whole hemisphere, reaching halfway around the globe at its widest point. It is bigger than all the land put together and contains almost half of all the water on the Earth. The southern hemisphere containing less land is also known as water hemisphere.

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The Global Positioning System (GPS)

The Global Positioning System (GPS) comprises 24 orbiting satellites that transmit navigational signals for earth-bound use. Originally devised in the 1970s by the Department of Defence for military purposes, the GPS in its present form is now commercially available worldwide. A hand-held receiver about the size of a pocket radio accesses three satellites at the same time and calculates and displays your latitude and longitude, accurate within 40 to 100 m (precision down to millimeters) is possible for military applications.

GPS is useful for such diverse applications like ocean-navigation, land surveying, commercial fishing, tracking and the monitoring of highway taxes, mining and resource-mapping, farming, environmental planning and as of 1994, airlines began using GPS to improve routes and increase fuel efficiency. GPS is also available for the back-packer and sportspersons. The importance of GPS to geography is obvious because this precise technology reduces the need to maintain ground control points of location, mapping, and spatial analysis.

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Chapter Two

Geomorphology

Chapter Concepts

- Earth's Four Spheres
- Geomorphology
- The Interior of the Earth
- Rocks
- Continental Drift
- Plate Tectonics
- Continental Relief
- Volcano
- Earthquakes
- Denudation

Earth's Four Spheres

Earth's surface is where four open systems interface and interact **(Fig. 2.1).** It may be seen from Figure 2.1 that the three abiotic (non-living) systems are overlapping to form the realm of biotic (living) system. The abiotic spheres are the *atmosphere, hydrosphere* and *lithosphere*. The biotic sphere is called the *biosphere*. Because these four spheres are not independent units in nature, their boundaries must be understood as transitional rather than sharp delimitations.

Atmosphere

The atmosphere is a thin, gaseous envelop surrounding the Earth, held by the force of gravity. Formed by gases arising from within the Earth's crust and interior, and the exhalations of all life over time, the lower atmosphere is unique in the solar system. It is a combination of nitrogen, oxygen, argon, carbon dioxide, water vapour, and small amount of trace gases.

Hydrosphere

Earth's water exists in the atmosphere, on the surface and in the crust near the surface, in liquid, solid, and gaseous states. Water occurs in two forms, fresh and saline (salty), and exhibits important heat properties as well as plying its extraordinary roles as a solvent. Among the planets in the solar system, only the Earth possesses sufficient water in quantity.

Lithosphere

Earth's crust and a portion of the upper mantle directly below the crust form the lithosphere. The crust is quite brittle compared to the layers beneath it, which are in motion in response to an uneven distribution of heat and pressure. In broad sense, the term lithosphere sometimes refers to entire solid planet.

Biosphere

The intricate, interconnected web that links all organisms with their physical environment is the biosphere. Sometimes called the *ecosphere*, the biosphere extends from the seafloor to about 8 km (5 miles) into the atmosphere. Biosphere

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is that area where the atmosphere, lithosphere, and hydrosphere function together to form the context within which life exists; an intricate web that connects all organisms with their physical environment. Life is sustainable within these natural limits. In turn, life processes have powerfully shaped the other three spheres through various interactive processes. The biosphere has evolved, reorganised itself at times, faced extinction, gained new vitality, and managed to flourish overall. Earth's biosphere is the only one known in the solar system; thus, life as we know is unique to the Earth.

Today, over six hundred million humans, approximately one million animal species and 355,000 known plant species depend on the air, water and land of the planet Earth.

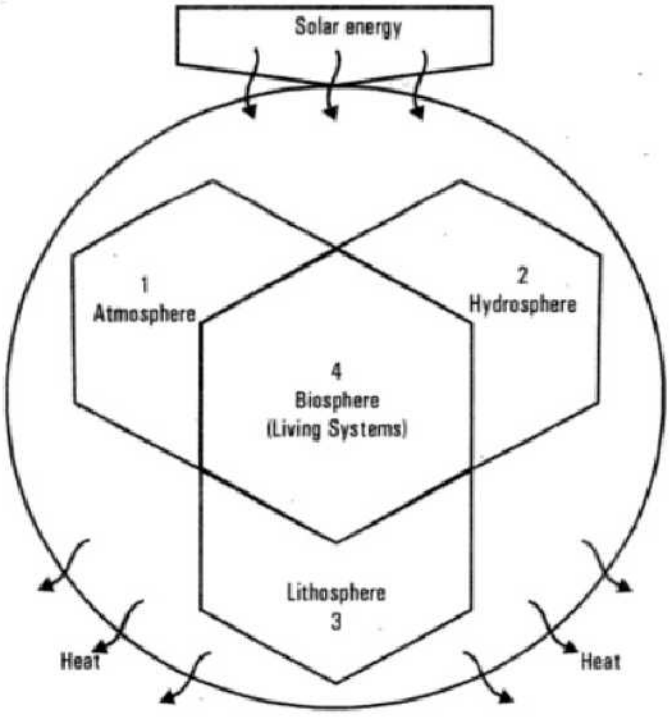

Fig. 2.1 – Four spheres of the Earth

Geomorphology

The science that analyse and describe the origin, evolution, form, classification, and spatial distribution of landforms is known as geomorphology. The term that arose in the Geological Survey in the USA in the 1880s, possibly coined by J.W. Powell and W.J. McGee. He regarded geomorphology as being that part of geology which enabled the geomorphologists to construct earth history by looking at the evidence for past erosion. In recent years there has been a tendency for geomorphologists to become more deeply involved with understanding the processes of erosion, weathering, transport and deposition, with measuring the rates at which such processes operate, and with quantitative analysis of the forms of the ground surface (morphometry) and of the materials of which they are composed. Geomorphology now has many component branches, e.g. Anthropogeomorphology; Applied Geomorphology.

The Interior of the Earth

The interior of the Earth and its constitution has always been a matter of great controversy among the geologists and geomorphologists. In the absence of direct evidence, the interior of the Earth was estimated with the help of change in temperature, pressure and density with depth. A reliable picture of the physical constitution of the Earth was however, ascertained with the help of seismic waves.

Earthquake Waves and Interior of the Earth

The behaviour of the earthquake waves in the different layers of the Earth provides the most authentic evidence about the composition and structure of the Earth. For example, when an earthquake or underground nuclear test sends shock waves through the Earth, the cooler areas, which generally are rigid, transmit these waves at a higher velocity than the hotter areas.

The different types of waves generated during the occurrence of an earthquake are generally divided into three broad categories: (i) Primary waves, (ii) Secondary waves, and (iii) Surface waves. The behaviour of different types of earthquake waves in the different mediums (solid, liquid and gaseous) has been described as under:

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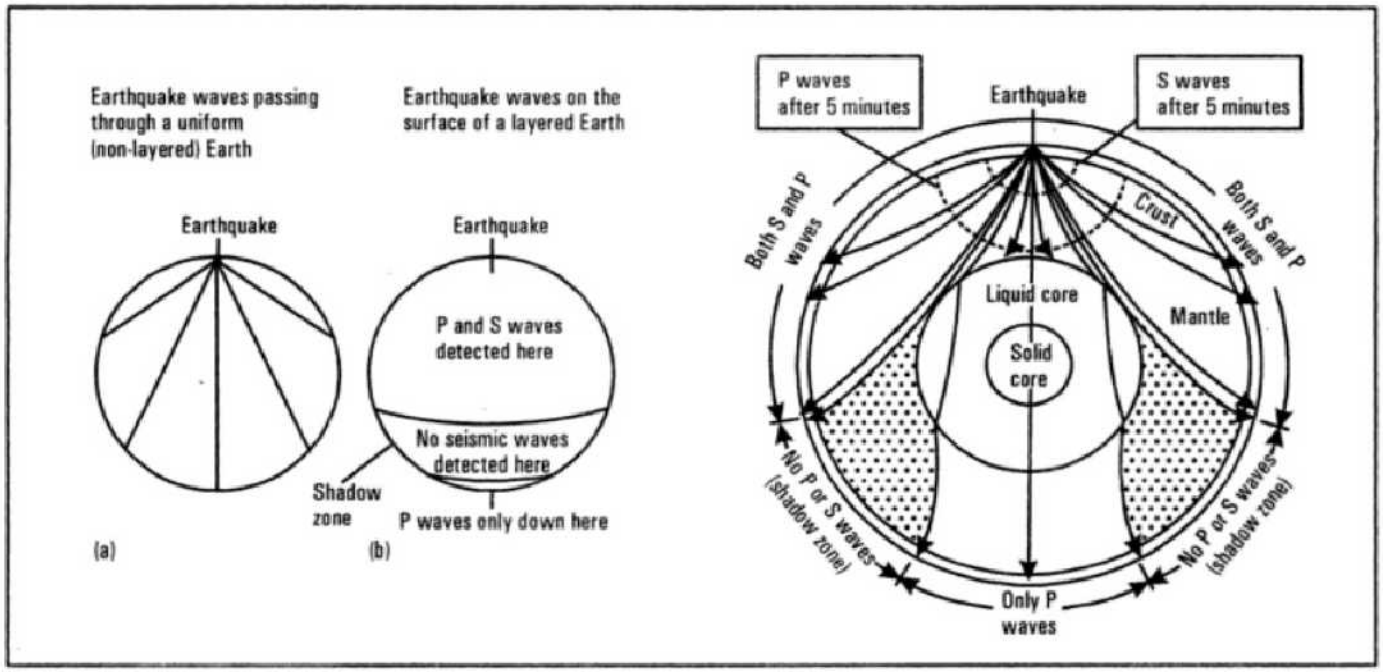
Primary Waves

These are also called as the longitudinal or compressional waves. In this type of wave motion, particles of the medium vibrate along the direction of propagation of the wave. These are the high frequency, short wave length, longitudinal waves. These waves travel not only through the solid part of the earth but also through the liquid part of the core. A primary wave travels with fastest speed through solid and more dense materials, and under certain circumstances, it changes into a secondary wave on refraction, or vice versa. In the liquid materials, their speed is slowed down. These waves are analogous to sound waves wherein particles move to and fro in the line of propagation of the ray **(Fig. 2.2).**



Seismic Wave model: How earthquakes contributed to our model of the layered earth.

(a) If the earth were homogeneous throughout, seismic waves would travel in straight-line paths at constant speed.

(b) Actually, the earth has a dense core, producing a shadow zone in which no seismic waves are detected.

(c) The patterns of reflected and refracted waves helped geophysicists deduce the structure of the earth's layers (after T. Garrison).

Fig. 2.2 – Seismic waves inside the Earth

Secondary Waves

These are also called as transverse or distortional waves. Secondary waves are analogous to water ripples or light waves, wherein the particles move at right angles to the rays **(Fig. 2.2)**. A secondary wave cannot pass through liquid materials. These are the high frequency, short wave-length waves which are propagated in all directions from the focus and travel at varying velocities (proportional to density) through the solid part of the Earth's crust, mantle and core. The shallow zone of 'S' waves extends almost halfway around the globe from the earthquake's focus. This can be explained if the outer core of the Earth is liquid. Since S waves cannot travel through liquid, they do not pass through the core.

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Surface Waves

Surface waves are called long period waves. These waves generally affect the surface of the Earth only and die out at smaller depth. The surface waves are characterised with low frequency, long wavelength, and transverse vibration which develop in the immediate neighbourhood of the epicenter. These waves are responsible for most the destructive force of earthquake. They cover the longest distance of all the seismic waves and recoded in the last at the seismograph.

Seismic Waves as Probes of Earth's Interior

Seismic waves passing through the earth are refracted in ways that show distinct discontinuities within the Earth's interior and provide the basis for the belief that the Earth has: (i) a solid inner core, (ii) a liquid outer core, (iii) a soft asthenosphere, and (iv) a rigid lithosphere.

If the Earth were a homogeneous solid, seismic waves would travel through it at a constant speed. A seismic ray (a line perpendicular to the wave front) would then be a straight line as shown in **Fig. 2.2**. Early investigations, however, found that seismic waves arrive correspondingly sooner than was expected at stations progressively farther from an earthquake's course. The rays arriving at a distant station travel deeper through the Earth than those reaching stations closer to the epicenter. Obviously, then, if travel times of long-distance waves are progressively shortened as they go deeper into the Earth, they must travel more rapidly at depth then they do near the surface. The significant conclusion drawn from these facts is that the Earth is not a homogeneous, uniform mass, but has physical properties that change with depth. As a result seismic rays are believed to follow curved paths through the Earth **(Fig. 2.2)**.

Seismic Discontinuities

Seismologists have located two major layers which separate zones within the Earth having markedly different properties. The outer one – Mohorovicic Discontinuity (Moho) – separates the crust from the mantle, its average depth being about 35 km. The second discontinuity lies between the mantle and the outer core known as Gutenberg Discontinuity which is about 2900 km.

Thus, the Earth is a differentiated planet, that is, its constituent materials are separated and segregated into layers according to density. The denser materials are concentrated near the centre, the less dense near the surface. The internal layers are recognised on the basis of composition, and physical properties. The chemical compositional layers are: (1) crust, (2) mantle, and (3) core. Layers based on physical properties are: (i) lithosphere, (ii) asthenosphere, (iii) mesosphere, (iv) outer core, and (v) inner core.

The Crust

The outermost layer, or shell, of the Earth is known as crust. The Earth's crust is generally defined as the part of the Earth above the Mohorovicic (Moho) discontinuity. It is rigid and represents less than 1% of the Earth's total volume **(Figs. 2.3 & 2.4)**.

Mantle

The zone of Earth's interior between the base of crust (the Moho-Discontinuity) and the core. The depth of mantle varies between 35 km and 2900 km. The density ranges from 3.3 to 5.7 in the lower part. The density varies between 2.9 and 3.3. It is composed of solid rock and magma **(Figs. 2.3 & 2.4)**.

Core

The central part of the Earth below a depth of 2900 km is known as core. It consists of a dense nickel-iron alloy (*nife*) with a temperature estimated at about 2700°C. The outer core is liquid while the inner core is solid. The 'S' waves, which can pass only through solid subjects, suddenly disappear at the depth of 2900 km **(Figs. 2.3 & 2.4)**.

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To conclude, the velocities of P waves and S waves through the Earth indicate that the Earth has a solid inner core, a liquid outer-core, a thick mantle, a soft asthenosphere, and a rigid lithosphere **(Figs. 2.2 & 2.4)**

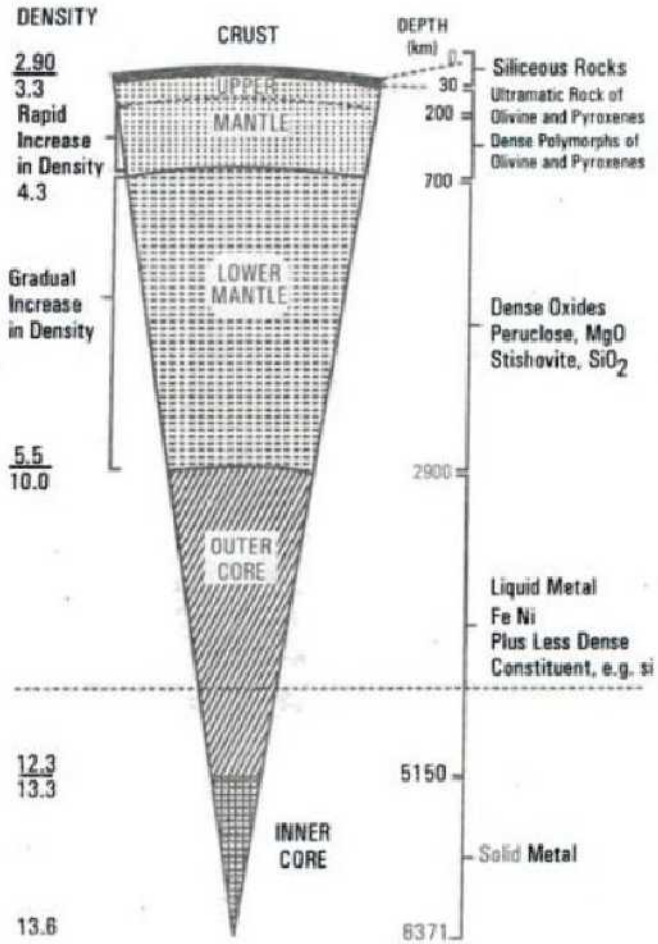

Fig. 2.3 – A Schematic section of the Earth

Rocks

Rock is an aggregate of minerals that forms an appreciable part of the lithosphere. The most important rock forming minerals are feldspars, micas, amphiboles, pyroxenes, olivine, quartz, calcite, dolomite, clays, and gypsum. On the basis of origin, and mode of formation, rocks may be classified into: (i) igneous, (ii) sedimentary, and (iii) metamorphic.

Igneous Rocks

Rocks formed by the cooling and solidification of molten silicate minerals (magma). Igneous rocks include volcanic and plutonic rocks. Igneous rocks are classified on the basis of texture and composition. The major kinds of igneous rocks are basalt, gabbro, andesite, diorite, rhyolite, and granite. Igneous rocks may also be classified under intrusive and extrusive rocks:

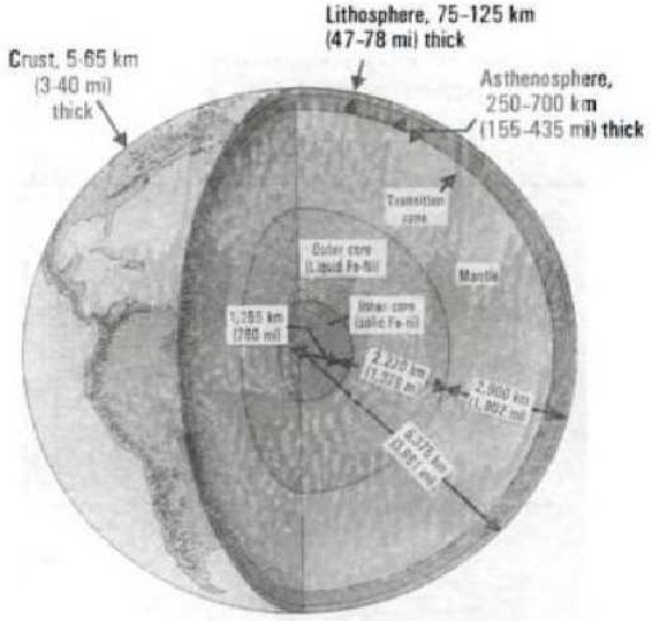

Fig. 2.4 – Major of Earth's interior after Conte Thompson, Moses, Earth Science, 1977, p.35.

Intrusive Rocks

These are the igneous rocks that, penetrated into or between other rocks in their fluid state and solidified. It can later be exposed at the Earth's surface after erosion of the overlying rock. A section of the intrusive rocks has been shown in **Fig. 2.5**.

Batholith

The term is applied to any large intrusive mass of igneous rock (almost always granite) in which there is no observable bottom of the

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structure. A batholith usually exposed over an area of at least 100 sq km **(Fig. 2.5)**.

Laccolith

Laccolith is an intrusive, dome-like mass of igneous rock which arches the overlying sediment and has more or less flat floor **(Fig. 2.5)**.

Sill

A tabular body of intrusive rock injected between layers of the enclosing rocks **(Fig. 2.6)**.

Dike (Dyke)

Dike a tabular intrusive rock that occurs across strata or other structural features of the surrounding rock **(Fig. 2.6)**.

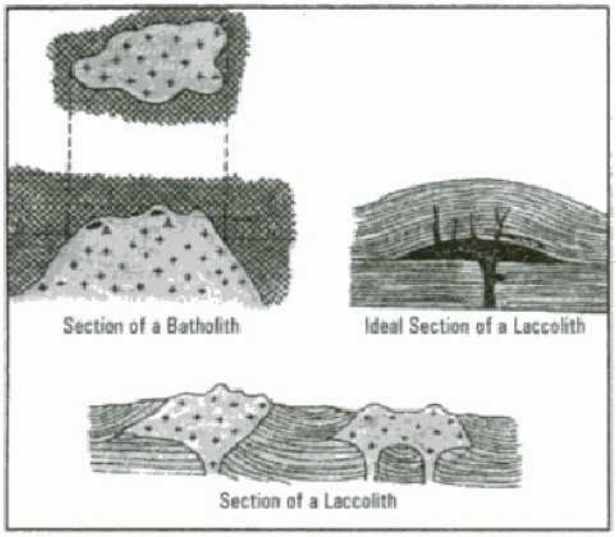

Fig. 2.5 – Section of Intrusive Rocks.

Phacolith

A concave-convex body of igneous rock which is inclinal in form, i.e. the concave surface is downward. Occasionally gold-quartz veins, occur in this form and are called saddle reefs.

Stock

A small, roughly circular intrusive body, usually less than 100 sq km in surface exposure

Zeolites

Zeolite is a large group of tekto (silicates) which contain true water of crystallisation. Zeolites occur in cavities in basic volcanic rocks and are thought to be product of hydrothermal activity.

Extrusive Igneous Rocks

Rocks formed by solidification of magma above the Earth's surface are known as extrusive igneous rocks.

(i) Explosive Rocks

These igneous rocks are the results of volcanic materials in which bombs, lapilli, dust and ash are deposited.

(ii) Quite Types

Lava comes out through minor cracks and fissures. After being cooled, the lava acquires the shape of basaltic igneous rocks. Most of the lava plateaus of the world are the results of fissure eruptions of lava **(Fig. 2.7)**.

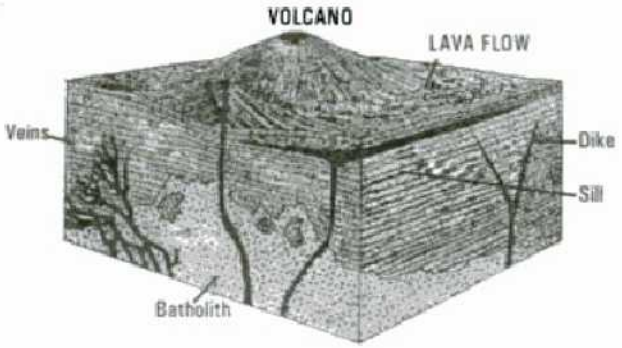

Fig. 2.6 – Various forms of intrusive igneous rock plutons and extensive lava flow (after A.Strehler)

Characteristics of Igneous Rocks

The main characteristics of igneous rocks are as under:

1. These rocks are solidified from molten magma.
2. They usually do not occur in distinct beds or strata.
3. Igneous rocks are generally not fossiliferous.
4. They are generally hard and water percolates in them with great difficulty along the joints.
5. Igneous rocks are granular and crystalline. The size of crystals, however, differs from one rock to another.

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6. These rocks are generally weathered by mechanical (physical) weathering.
8. Igneous rocks are mostly associated with the volcanic activity.
9. Most igneous rocks consist of silicate minerals.
10. The valuable minerals like iron-ore, copper, gold, silver, zinc, lead, manganese, mica, etc. are generally found in the igneous rocks.

Sedimentary Rocks

Rocks formed by the accumulation and consolidation of sediment are known as sedimentary rocks. Sedimentary rocks may be of the following types:

Argillacous (Aquueous Rocks)

A group of detrital sedimentary rocks deposited in water. They are commonly, clay, shale, mudstones, siltstones, and marl.

Argillaceous sedimentary rocks are further subdivided into:

(i) Marine argillaceous sedimentary rocks,

(b) Lacustrine argillaceous sedimentary rocks,

(iii) Riverine argillaceous sedimentary rocks.

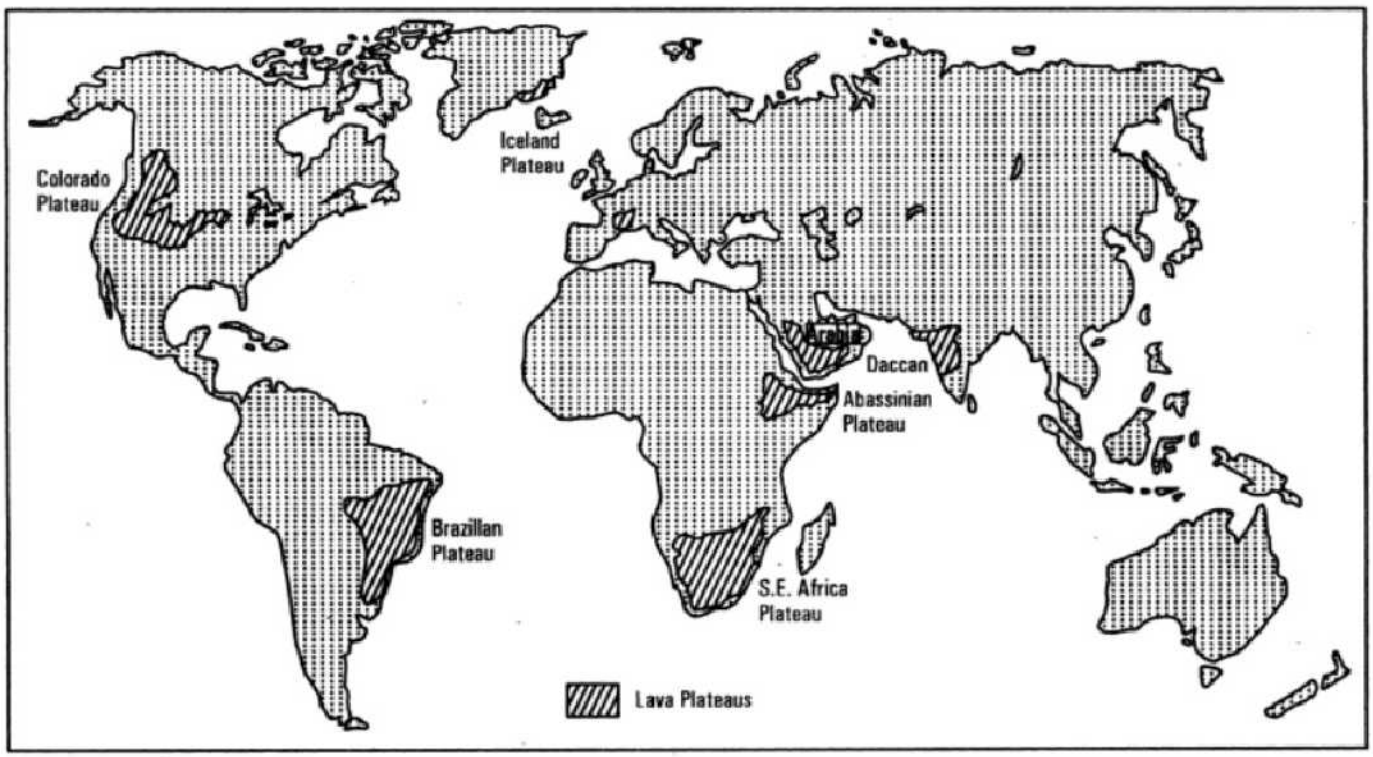

Fig. 2.7 – Main lava plateaus of the world

Aeolian

Sediments deposited after transported by wind are known as aeolian deposits. Loess is one of the most important aeolian deposits. The loess deposits are found away from the source region and outside the desert. The dust particles of loess are so small that they hold together even when dry and once deposited cannot be easily lifted by the wind. Loess is coherent (bound together) but not cemented and hence is permeable. Lack of stratification is a clear proof of its Aeolian origin. The equatorial tropics are free from loess because it is washed away by heavy rainfall as soon as it is deposited. The most extensive loess deposits in the world are in North China **(Fig. 2.8)**.

There caves and houses are carved out of the thick deposits. Loess deposits are also found in North European Plain, the Asiatic Steppe, Central North America and Argentina.

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Glacial

The sediments deposited by glaciers are called glacial sedimentary rocks. These deposits are also known as moraines.

Fig. 2.8 – Loess deposits in northern China

Characteristics of sedimentary rocks

The main characteristics of sedimentary rocks are as under:

1. The material of sedimentary rocks is derived from the pre-existing rock of any of the three rock classes as well as from newly formed organic matter. However, igneous rock is the most important original source of the inorganic mineral matter that forms sedimentary rock.
2. The sedimentary rocks contain layers or strata. They are, therefore, often called stratified rocks.
3. The layers of the sedimentary rocks are sometimes horizontal, and sometimes tilted due to lateral compressive and tensile forces.
4. Sedimentary rocks are deposited in seas and oceans in a sequential order.
5. Sedimentary rocks are characterised by joints of different sizes.
6. Most of the sedimentary rocks are permeable and porous.
7. Sedimentary rocks contain fossils.
8. Sedimentary rocks may be well consolidated, poorly consolidated and even unconsolidated.
9. The riverine sedimentary rocks develop cracks when exposed to the Sun. These cracks are generally of polygonal shape.

Metamorphic Rock

These rocks are formed from pre-existing rocks within the Earth's crust due to changes in temperature, pressure and chemical action of fluid. The main examples of metamorphic rocks are slate, marble, quartzite, schist, and gneiss **(Fig. 2.9)**.

Gneiss

Gneiss is a coarse-grained, banded, crystalline rock resulting from high grade regional metamorphism.

Marble

Limestone, after undergoing metamorphism becomes marble. Marble is produced under conditions of thermal metamorphism.

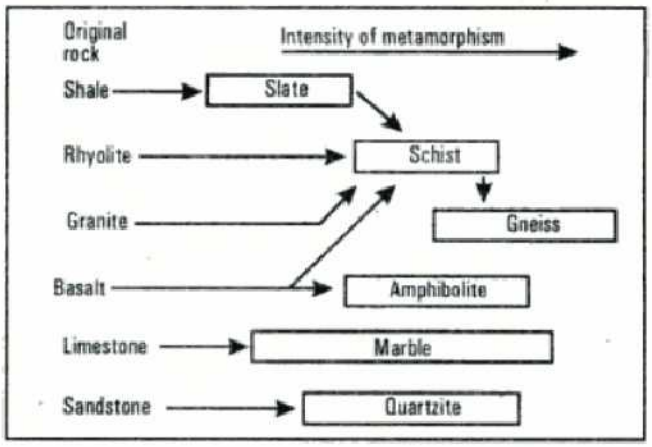

Fig. 2.9 – The origin of common metamorphic rocks is complex. In some cases, such as quartzite, marble, and metaconglomerate (not shown in diagram), the nature of the original rocks is easily determined. In other cases, such as schist and gneiss, it is difficult and sometimes impossible to determine the type of source rock. This diagram is a simplified flowchart showing the origin of some of the common metamorphic rocks.

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Phyllite

Phyllite is a cleaved metamorphic rock having affinities with both slate and mica-schist.

Quartzite

Quartzite is a metamorphosed arenaceous rock. Quartzite is a metamorphic equivalent of conglomerate, sandstone and silt-stone, which is formed by the addition of silica to fill completely the open spaces between grains.

Schist

Schist is a well foliated, medium to coarse-grained metamorphic rock created by the effect of regional metamorphism.

Slate

Slate is a very fine-grained metamorphic rock, generally produced by the low-grade metamorphism of shale. It is characterised by excellent foliation, known as slaty cleavage.

Characteristics of metamorphic rocks

The main characteristics of metamorphic rocks are as under:

1. Metamorphic rocks are formed due to change in texture and mineral composition of the pre-existing rocks.
2. Some rocks after metamorphism become more hard than their original form. For example, marble from limestone, quartzite from sandstone, and diamond from carbon.
3. The fossils of the original sedimentary rocks are destroyed and, therefore, they do not contain fossils.
4. The coarse-grained metamorphic rocks are imperfectly foliated, e.g. gneisses, from granites, while the fine–grained metamorphic rocks are perfectly foliated, e.g. schist from shale.
5. Many of the metamorphic rocks are impervious (marble and slate), and some of them are pervious, e.g. gneiss.
6. Many of the metamorphic rocks may split along the bedding planes, e, g., micaschist.
7. Most gneissic metamorphic rocks comprise bands of granular quartz and feldspar.

Continental Drift

The movement of continents relative to each other across the Earth's surface is known as continental drift. Although it was a subject of speculation by numerous early workers, the first comprehensive case of continental drift was presented by the German meteorologist, polar explorer, astronomer, and geologist, Alfred Wegener in 1914. Wegener suggested that all the Earth's land had once been joined into a single supercontinent, surrounded by an ocean.

He called the land mass Pangaea (Pan = all + gaea = Earth) and the surrounding ocean Panthalassa (Pan = all + Thalassa = ocean). Wagener thought Pangaea had broken into pieces during the Carboniferous period. Since then, the pieces had moved to their present positions and are still moving **(Fig. 2.10)**.

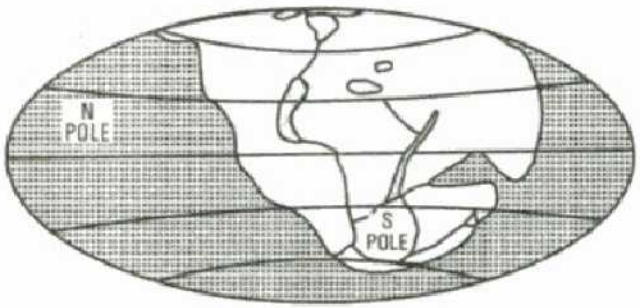

Fig. 2.10 – Pangaea

Wegener cited various evidence in support of his theory of super continent (Pangaea) which gradually separated into Northern (Laurasia) and the Southern (Gondwanaland) landmass before finally splitting into continents of the present day.

Wegener's evidence included the apparent shore fit of continents across the North and South Atlantic. The evidence included the matching configuration of opposing continental coastlines, the similarity of geological structures on separate continental masses, the anomalous location of ancient deposits, indicating specific climatic conditions, and distribution of fossil species through time **(Figs. 2.11 and 2.12)**.

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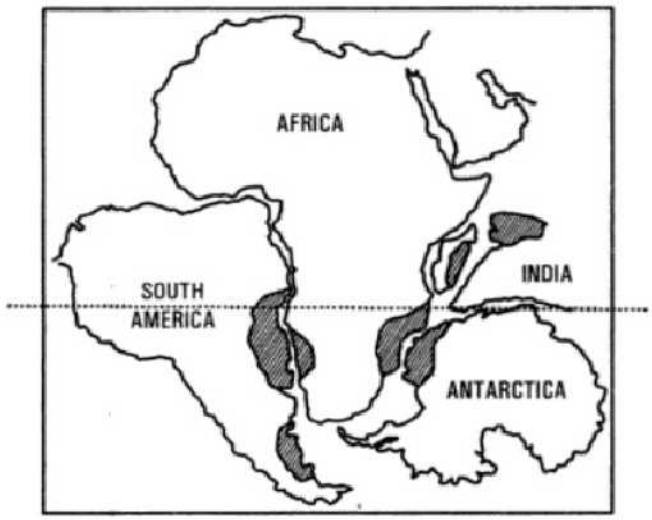

Fig. 2.11 – Jig-saw fit of continents and major basalt plateaus

He believed that the continents were slung towards the equator on the spinning Earth by a centrifugal effect, while the westward movement of the continents was due to the tidal force of the Moon and the Sun. The theory was rejected first by most geologists and geophysicists, largely because of a lack of viable mechanism. Wegener was dismissed as a crank. His critiques claimed, with some justification, that he had carefully selected those evidence, supporting his hypothesis, ignoring contrary evidence. Where, for instance, were the 'wakes' or 'tracks' through old seabed that the migrant continents would leave? But a few geologists sided with Wegener. Further support for continental drift was provided during the 1950s and 1960s through evidence from Palaeomagnetism. In 1967 the idea was incorporated into the theory of Plate Tectonics.

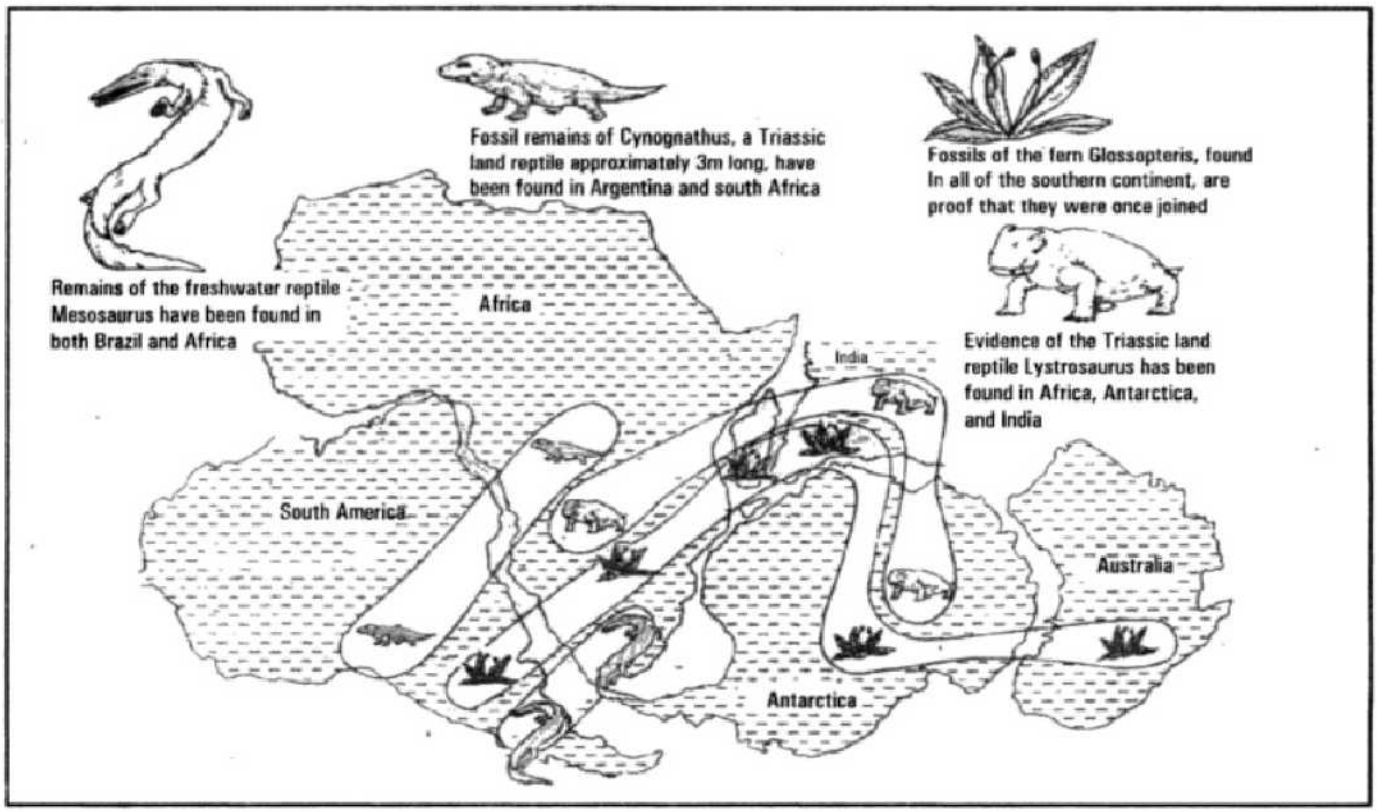
Fossil remains of Cynognathus, a Triassic land reptile approximately 3m long, have been found in Argentina and south Africa
Fossils of the fern Glossopteris, found in all of the southern continent, are proof that they were once joined
Remains of the freshwater reptile Mesosaurus have been found in both Brazil and Africa
Africa
India
Evidence of the Triassic land reptile Lystrosaurus has been found in Africa, Antarctica, and India
South America
Australia
Antarctica

Fig. 2.12 – Paleontological evidence of Continental Drigt (after Hamblin, 1995)

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Plate Tectonics

The Earth's crust is made up of seven major and several minor rigid continental and oceanic tectonic plates, which fit closely together. These plates are constantly moving relative to one another **(Fig. 2.13)**. The type of movement between plates affects the way in which they alter the structure of the Earth. The oldest parts of the plates, known as shields, are the most stable parts of the Earth and little tectonic activity occurs here.

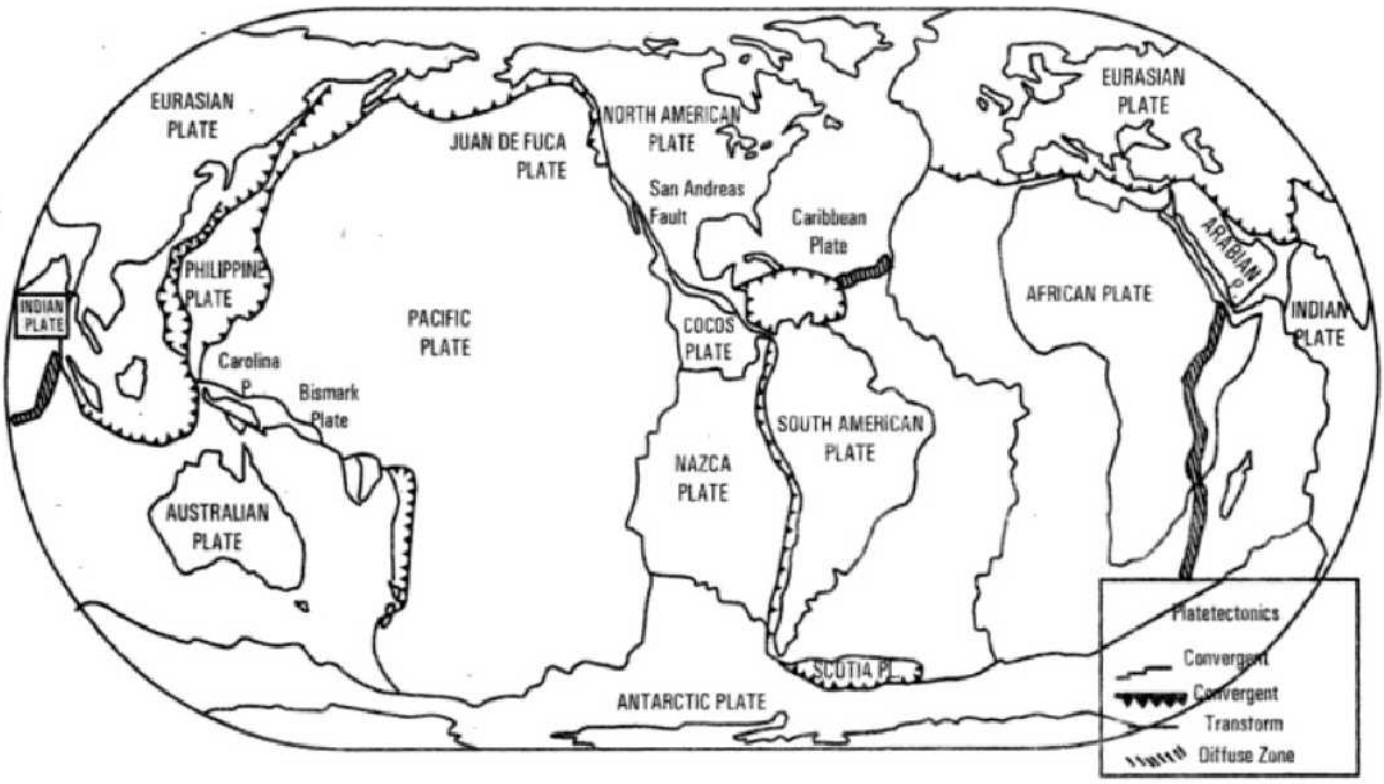

Fig. 2.13 – Major and minor plates

Plate Boundaries

The boundaries between the plates are the areas where most tectonic activity takes place. Three types of movement occur at plate boundaries: (i) the plates can either move toward each other,(ii) move apart, and (iii) slide past each other. The effect of this movement on the earth's structure depends on whether the margin is between two continental plates, two oceanic plates, or an oceanic and continental plates.

(i) Convergent or destructive plate margin (subduction)

When the plates move towards each other **(Fig. 2.14)**, such margins are called convergent or destructive plate margin. The oceanic crust is denser and thinner than that of continental crust: on an average 5 km (3 miles) thick, while continental crust averages 30-40 km (18-24 miles). When oceanic plates of similar density meet, the crust is contorted and one plate overrides the other, forming deep sea trenches and volcanic island arcs above sea level. The Andes mountains is a typical result of the impact of convergent.

The Alps were formed when the African plate collided with the Eurasian plate about 65 million years ago. Similarly, the Himalayas are the results of the colliding of the Indian plate with the Eurasian plate.

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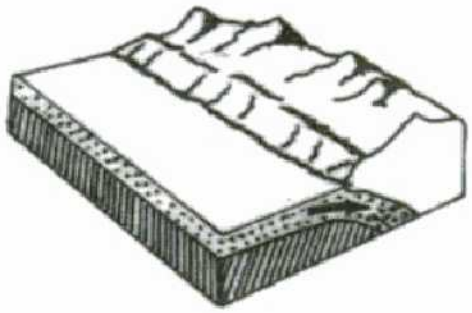

Fig. 2.14 – Convergent plate boundaries

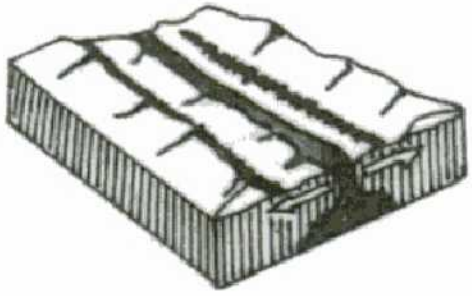

Fig. 2.15 – Divergent plate boundaries

(ii) Divergent or constructive plate margins

When the plates move away (apart) from each other, such margins are called divergent of constructive margins **(Fig. 2.15)**. The divergence of plates allows magma to force its way up to surface. The oceanic ridges are constructed because of the divergence of plates.

Vast amounts of volcanic materials are discharged at the mid-oceanic ridges which can reach heights of 3000 m (about10,000 feet).

The Mid-Atlantic ridge rises above sea level in Iceland, producing geysers and volcanoes.

The Eyjafjoell volcano of Iceland, erupted on 17.4.2010 was on the divergent plate of the Atlantic ocean.

(iii) Shearing or neutral plate margins

When the plates slide past each other, they neither construct the earth-crust nor destroy it. When two plates slide, past each other, friction is caused along the fault line which divides them.

The plates do not move smoothly, and the uneven movement causes earthquakes. The deep fracture caused by the sliding plates of San Andreas Fault (California-USA) is one of such examples **(Fig. 2.16)**.

Ring of Fire

The concept of 'Ring of Fire' was given by Hugo Benioff (a seismologist) in 1940. He plotted the locations of deep earthquakes at the edges of the Pacific Ocean. His maps revealed the true extent of 'Ring of Fire'- a circle of violent volcanic activity surrounding much of the Pacific ocean **(Fig. 2.17)**. According to Benioff, Wadati, Japanese seismologist, deep earthquakes did not occur randomly over the Earth's surface but were concentrated in zones that extended in lines along the earth's crust. Benioff and others wondered what could cause such an orderly pattern of deep earthquakes. Many of the lines corresponded with a worldwide system of oceanic ridges, (plotted for the first time in 1928 by Meteor oceanographers) while working in the Middle Atlantic. The concept of 'Ring of Fire' helped in the development of new concepts of 'Seafloor Spreading' and 'Plate Tectonic'.

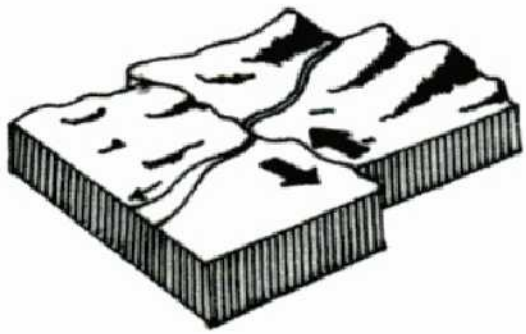

Fig. 2.16 – Transform plate boundaries

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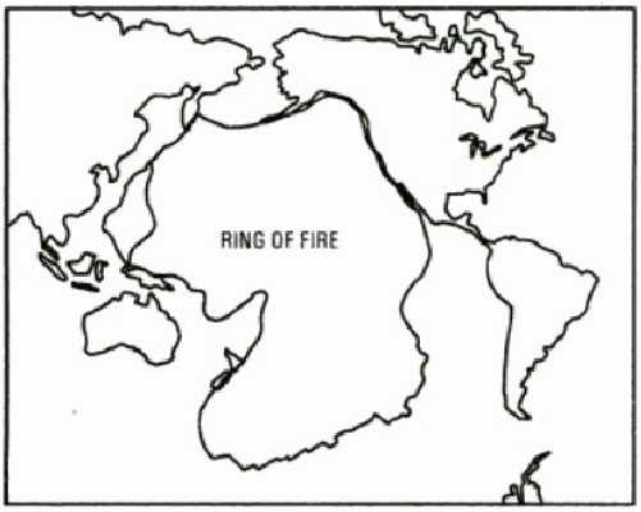

Fig. 2.17 – Ring of Fire

Seafloor Spreading

The concept of seafloor spreading was put forward by Professor H. Harry Hess of Princeton University in 1960. He suggested that new seafloor forms at the Mid-Atlantic Ridge (and the other newly discovered ocean ridges) and spreads outward from this line of origin. Continents would be pushed aside by the same forces that cause the ocean to grow. This motion could be powered by convection currents, slow-flowing circuits of material within the asthenosphere **(Fig. 2.18)**.

The theory of seafloor spreading solved many of the unsolved problems. It solved the problem of the younger age of the crust at the mid-oceanic ridges and older rocks as one moves away from the middle parts of the ridges. It also resolved why the sediments at the central parts of the oceanic ridges are relatively thin. Finally, the concept of seafloor spreading proved the drift of the continents as propounded by Wegener and helped in the development of the theory of Plate Tectonic.

Continental Relief

All the continents are characterised by shields, platforms, mountains, plateaus, plains, volcanoes, etc.

Continental Shield

The centres of the Earth's continents, known as shields, were established during the Pre-Cambrian Period (over 570 million years ago), some of them like the Canadian Shield contain rocks over three billion years old. They were formed by a series of turbulent events; plates movements, earthquakes, and volcanic eruptions. They have experienced little tectonic activity, and today, their flat, low-lying slabs of solidified molten rock form the stable centres of the continents. They are bounded or covered by successive belts of younger sedimentary rocks.The major continental shields have been given in **Fig. 2.19**.

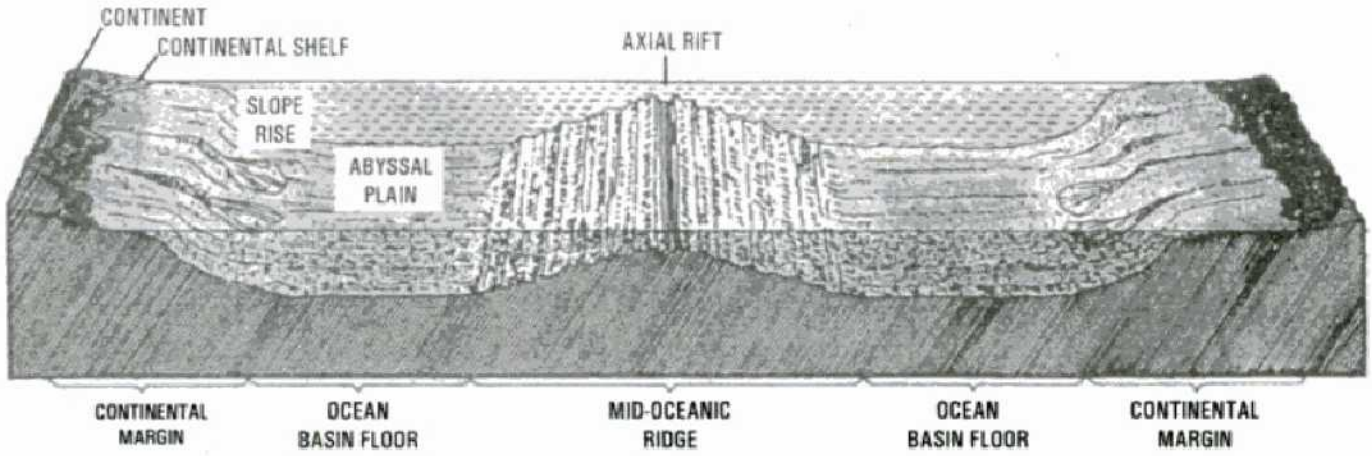

Fig. 2.18 – Sea floor - Spreading (after A.H. strahler et. al.)

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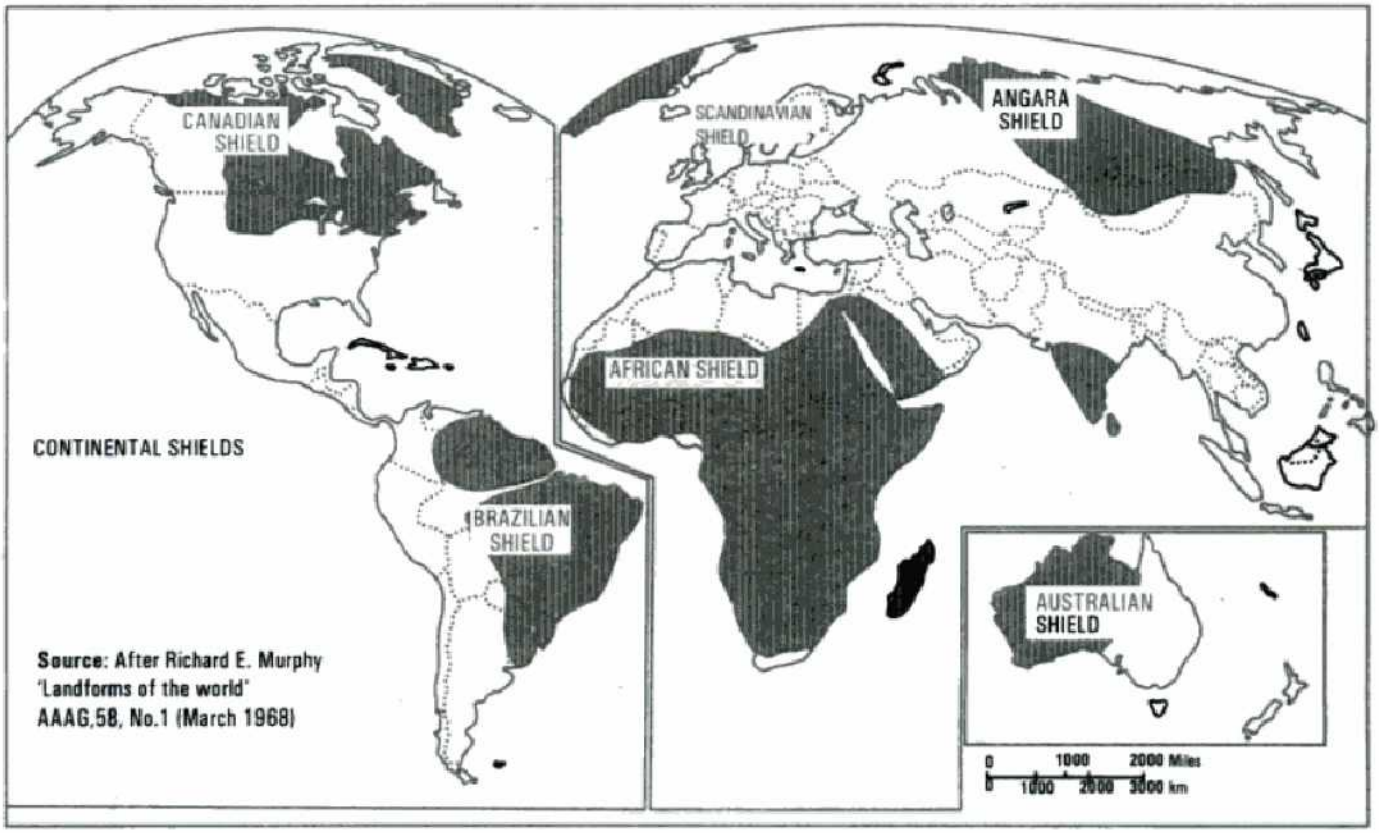

Fig. 2.19 – Major continental shields of the world

Mountain

Mountain can be single peak or part of a range. The summit of Mt. Everest is 8848 meters, the highest mountain range in the world is a part of the Himalayas. On the basis of their origin, the mountains may be classified into: (A) Folded, (B) Volcanic, (C) Fault Black, and (D) Dome-uparched of beds **(Fig. 2.20)**.

Plateau

Plateaus are vast areas of relatively flat land at high elevations. The Plateau of Tibet, located in China, is the highest plateau of the world.

Plain

Plains are broad stretches of nearly level land, usually found at low elevations. The fertile lowlands of North China plain and the Indo-Gangetic plains have the highly productive agricultural lands in the world. China plain ranges from 0 to 150 meters, while the Indo-Gangetic plain ranges from 0 to 300 metres above the sea level.

Elevation

Elevation is the measure of land's height or depth above or below the sea level.

Landforms

Landforms are the physical features of the landscape. Most extensive landforms have patterns of high, low, or changing elevation.

Relief

Relief is the difference between the highest and the lowest elevation of a landform, feature or a region.

Basin

Basins are low areas surrounded by higher grounds.

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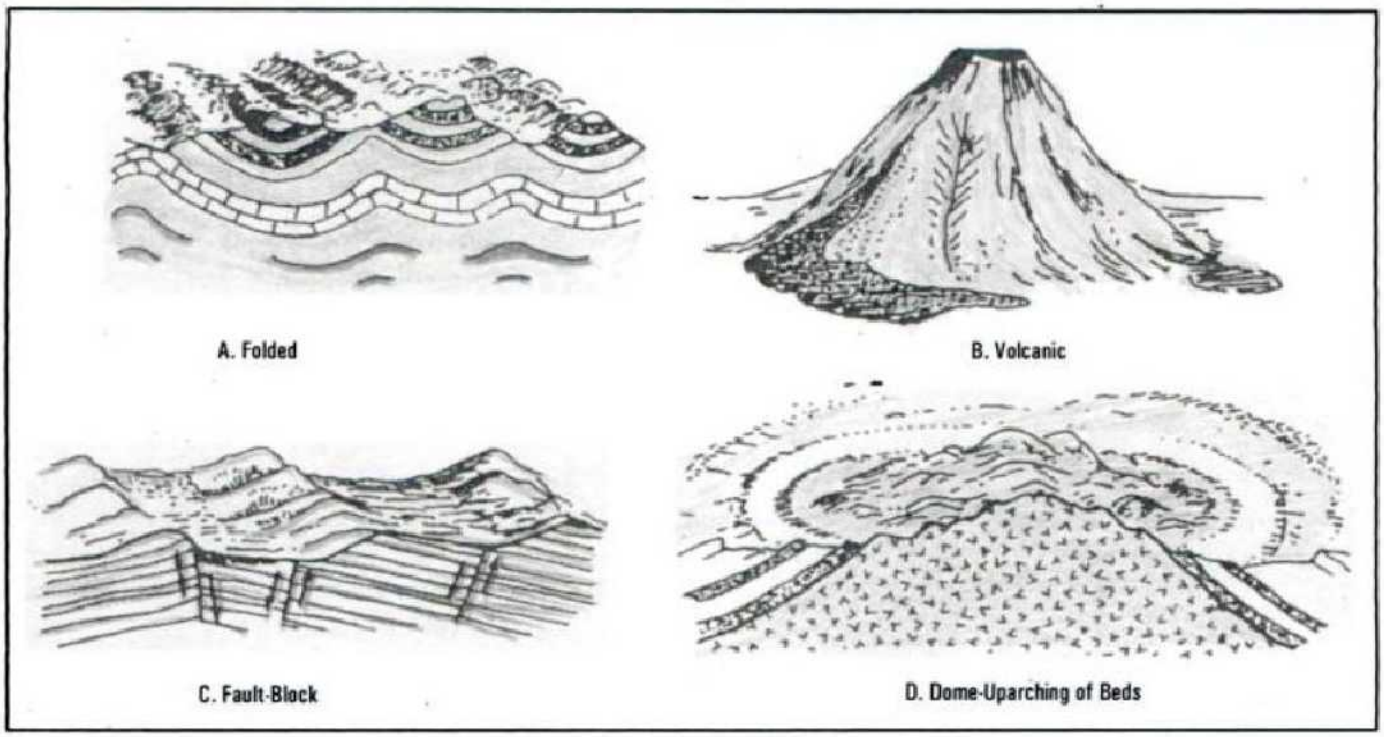

Fig. 2.20 – Classification of mountains

Volcano

Volcano is a landform at the end of a conduit or pipe which rises from below the crust and vent to the surface of the Earth. Magma rises and collects in a magma chamber deep below resulting in eruption that are effusive or explosive forming the mountain. An idealised cross section of a volcano has been given in **Fig. 2.21.**

The magma that actually issues from the volcano is termed lava (molten rock). Lava gases and tephra (pulverised rock and clastic materials ejected violently during eruption) pass through the vent to the surface and build a volcanic landform.

A cinder cone is a small cone-shaped hill usually less than 450 m (1500 ft) with a truncated top formed from cinders that accumulate during moderately explosive eruptions. Cinder cones are made of tephra and scoria. Another distinctive landform is a large basin shaped depression called caldera (Spanish from 'kettle'). It forms when summit material on a volcanic mountain collapses inward after an eruption or other loss of magma, forming a caldera that may fill with rainwater such as crater lake.

Composite Volcanoes

Composite volcanoes are built up of alternating layers of ash and lava flows, which characteristically form high, steep-sided cones **(Fig. 2.21).**

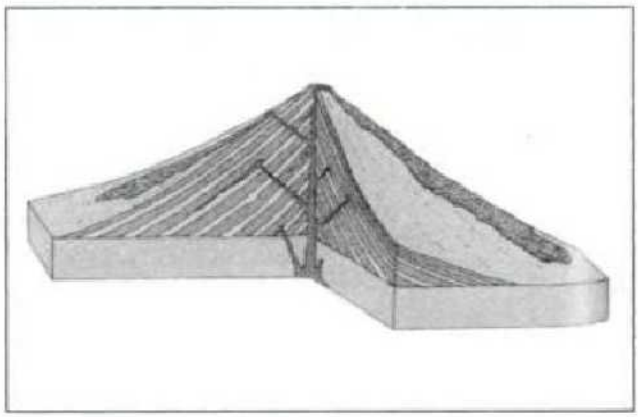

Fig. 2.21 – Composite volcanoes

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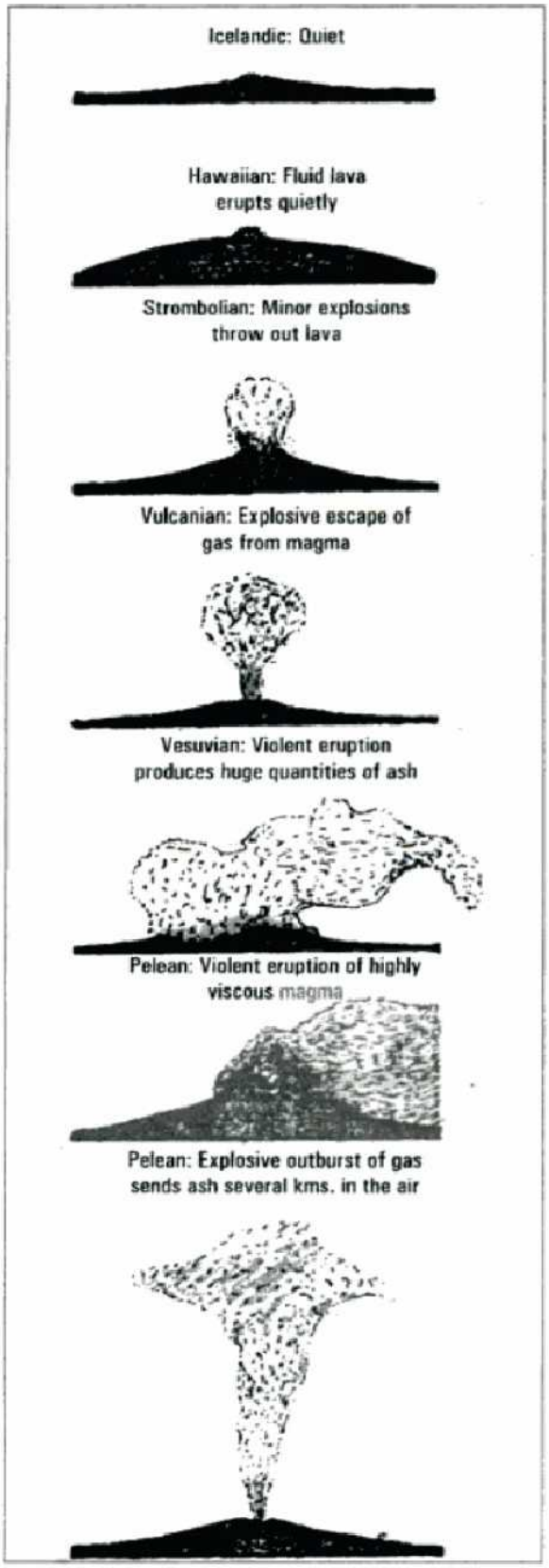
Icelandic: Quiet
Hawaiian: Fluid lava erupts quietly
Strombolian: Minor explosions throw out lava
Vulcanian: Explosive escape of gas from magma
Vesuvian: Violent eruption produces huge quantities of ash
Pelean: Violent eruption of highly viscous magma
Pelean: Explosive outburst of gas sends ash several kms. in the air

Fig. 2.22 – Types of vocanic eruptions

Types of Volcanic Eruptions

On the basis of mode of eruptions, numerous classifications of volcanoes have been given. The most commonly used classification of volcanic eruptions was given by Lacroix in 1908. According to Lacroix, there are four principal types of eruptions: (i) Hawaiian, (ii) Strombolian, (iii) Vulcanian, and (iv) Pelean **(Fig. 2.22)**.

(i) Hawaiian Eruption

It is an eruption in which large quantities of extremely fluid basic lava flow out from a fissure or a central vent to form a typical shield. In this type of volcano, explosive activity is almost absent **(Fig. 2.22)**.

(ii) Strombolian Eruption

In this type of volcanic eruption, the basic lave (basaltic) is less fluid than that of Hawaiian type. Consequently, explosions are more common and more gragmental material is ejected. It is named after the volcano on the island of Stromboli off north Sicily **(Fig. 2.22)**.

(iii) Vulcanian

In this type of eruption, the lava surface solidifies rapidly because of its high viscosity. The solidification results in building up of pressure beneath the lava crust and continuous series of violent explosions during which large quantities of pyroclastic materials are ejected violently from the vent. The ash coming out of the volcano may be distributed widely by the wind **(Fig. 2.22)**.

(iv) Pelean Eruption

In Pelean the lava is extremely viscous. It erupts generally in violent forms. One of its salient feature is the formation of *nuee ardentes* (glowing clouds). This type of volcanic eruption is named after Mt. Pelee (West Indies) where extremely violent eruptions have occurred including that of 1902 **(Fig. 2.22)**.

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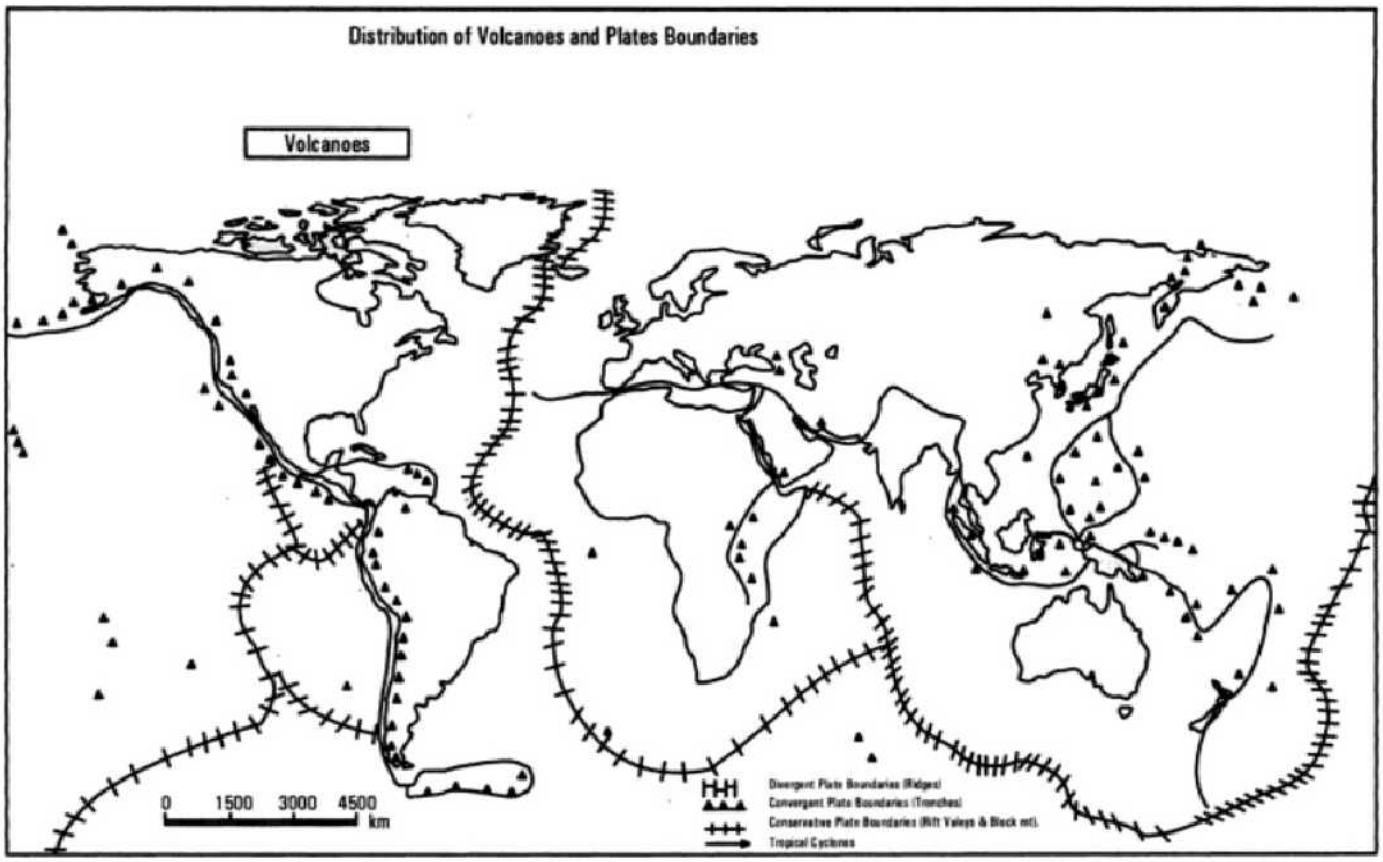

Fig. 2.23 – Plates margins and volcanoes

Distribution of Volcanoes in the World

There is a close relationship between the plates margin and the distribution of volcanoes in the world. In fact, the volcanoes are closely concentrated along the plates margin. The main concentration of the volcanoes lies in the following regions **(Fig. 2.23)**.

1. Along subduction boundaries at continental plate-oceanic plate convergence (Mount Saint Helens) or oceanic plate-oceanic plate convergence (Philippines and Japan).
2. Along seafloor spreading centres on ocean floor (Iceland) and areas of rifting on continental plates (the Rift Valley in East Africa).
3. At hot spots, where individual plumes of magma rise the crust (Hawaii Islands).

On the basis of periodicity, the volcanoes may be divided into the following three categories:
(i) Active volcanoes, (ii) Dormant volcanoes, and (iii) Extinct volcanoes

(i) Active Volcanoes

Volcanoes which constantly eject lava, gases, ashes, cinder, pumice, etc. are known as active volcanoes. At present, there are about 600 active volcanoes in the world, most of which are located in the Pacific ocean.

(ii) Dormant Volcanoes

A volcano which, although not extinct, has not been known to erupt within the historic time. The Vesuvius volcano (Italy) is one of the best examples of dormant volcano which erupted first in 79 A.D. It remained dormant for over 1550 years and then suddenly erupted with great force in 1631 A.D. The subsequent eruptions occurred in 1803, 1872, 1906, 1927, 1928, 1929. Kilimanjaro (Tanzania) is also an example of dormant volcano.

(iii) Extinct Volcanoes

A volcano that was active in distinct geological past and the remains of which occur in an area

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where there is no longer any volcanic activity is known as an extinct volcano. The crater is filled up with water converting it into a lake. The Arthur's seat (Edinbourg- capital of Scotland), Aconcagua (Andes), Sulaiman and Demavand in Elburz (Iran) are some of the examples of the extinct volcanoes **(Fig. 2.24)**.

Volcanoes and Society

Volcanic eruptions are the most popular spectacular of all the geographic phenomena. For centuries, they have caused dismay and terror for people who live in the volcanic belts.

Throughout the history of mankind, volcanoes have been a source of terrible destruction. They however, yielded life sustaining valuable mineral resources. Among the resources provided by volcanoes are rich volcanic soils, geothermal heat, metallic ores (including gold, silver, copper, molybdenum, beryllium, iron, lead, zinc, etc.), and the very air we breath and the water we drink. Industrial materials like building stones, sulfur, pumice, slate, dykes are the results of volcanic activity. Precious stones like diamond, gems have volcanic origin. The scenery of some of our most spectacular landscapes such as Laki, Eyjafjoell and Katla (Iceland), Kilimanjaro (Tanzania), Mt.Fuji (Japan), Lake Titicaca (Bolivia-Peru border) Pacific islands, Yellowstone Park (USA), etc. are the gifts of volcanoes. The eruption of volcano also bring climatic change.

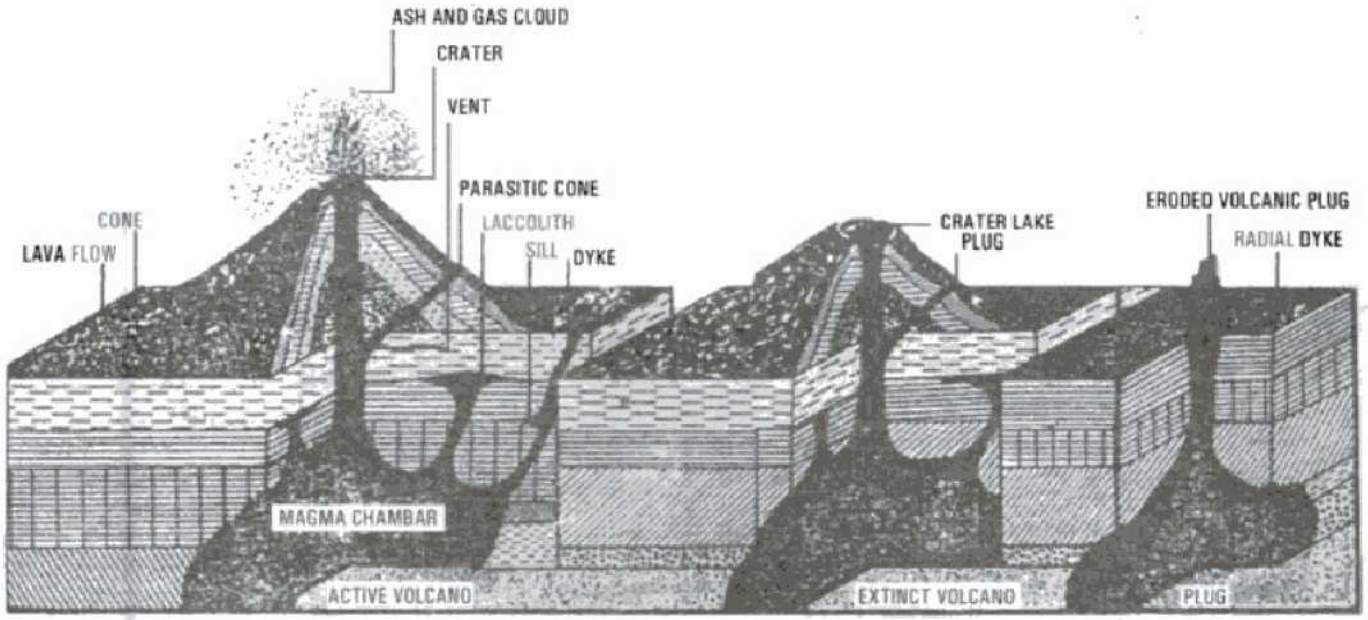

*Fig. 2.24 – Active and extinct volcanoes and **their main features*** (after The Encyclopedia of Earth's Resources, Exeter Books N.Y.)

***Table 2.1:** Main active volcanoes of the world.*

	Volcano	*Height in meters*	*Location*	*Country*	*Date of last eruption*
1.	Ojos del Salado	6885	Andes	Argentina-Chile	1981
2.	Guallatiri	6060	Andes	Chile	1960
3.	Cotopaxi	5897	Andes	Ecuador	1975
4.	Tupungatiti	5640	Andes	Chile	1964

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5.	Lascar	5641	Andes	Chile	1968
6.	Popocatepeti	5451	Altiplano de Mexico	Mexico	1920
7.	Navado del Ruiz	5400	Andes	Colombia	1985
8.	Sangay	5230	Andes	Ecuador	1976
9.	Klyuchevskaya	4850	Sredinny Khrebet	USSR	1974
10.	Purace	4590	Andes	Colombia	1977
11.	Mauna Loa	4170	Hawaii	USA	1978
12.	Mt.Cameroon	278	Monarch	Cameroon	1959
13.	Fuego	3836	Sierra Madre	Guatemala	1962
14.	Frebus	3795	Ross Island	Antarctica	1975
15.	Semru	3676	Java	Indonesia	1976
16.	Nyiragongo	3470	Virunga	Zaire	1977
17.	Mt. Etna	3308	Sicily	Italy	1979
18.	Agung	3142	Bali	Indonesia	1964
19.	Surtsey	173	S.E. Iceland	Iceland	1963
20.	Ana	155	Karakotoa	Indonesia	1929
21.	Mt. Unzen	-	Honshu	Japan	1991
22.	Mt. Mayon	-	Philipines	Philipines	1991, 1993
23.	Mt.Eyjafjoell tavel standstill in Europe	Brought air	Iceland	Iceland	17.04.2010

Earthquakes

Earthquakes are vibrations of the Earth, caused by the rupture and sudden movement of rocks that have been strained beyond their elastic limits. In other words, earthquake is a series of shocks and tremors resulting from the sudden release of pressure along active faults and in areas of volcanic activity. Earthquake magnitude is estimated by the Richter Scale, while intensity of the earthquake is described by the Mercalli Scale. The Richter Scale is open ended and logarithmic, i.e. each whole number on the scale represents a 10-fold increase in the measured wave amplitude. Translated into energy, each whole number demonstrates a 31.5-fold increase in the amount of energy released. The waves of the earthquakes are measured on *seismograph*. About 507,150 earthquakes are recorded annually out of which 50,000 are felt and one leads to total destruction.

Focus

The point of origin of an earthquake is known as focus.

Epicenter

The point of the Earth's surface which is directly above the focus of an earthquake is known as epicenter.

Causes of Earthquakes

The main causes of earthquakes are as under:

(i) Plate Tectonics

The Earth's crust is made up of seven major and several minor plates, which fit closely together. The positions of the plates are not static. They are constantly moving relative to one another. The type of movement between

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plates affects the way in which they alter the structure of the Earth. The oldest parts of the plate, known as shields are the least susceptible to earthquakes. Most of the earthquakes occur along the boundaries of the major and minor plates.

(ii) Volcanic Eruption

Volcanic eruption is one of the main causes of earthquakes. Volcanic earthquakes are caused by plates movements, gas explosion, the up-doming, fracture of rocks and fissuring of volcanic structures. Such earthquakes occur either simultaneously with eruption or more commonly in the period preceding an eruption.

(iii) Folding and Faulting (compression and fracture of rocks)

Folding of rocks due to compressional forces lead to earthquakes. Fault is the fractured surface in the Earth's crust along which rocks have travelled relative to each other. It is a surface along which a rock body has broken and been displaced. Earthquakes occur when movement of Earth takes place along a line of fracture called a fault. The San Andreas Fault of California is a typical example which led to earthquakes at Los Angles in 1906. The massive earthquakes of March 11, 2011 in Japan was the result of subduction of the Pacific plate underneath Japan (N. Honshu) at Japan Trench and dips to the west beneath the Eurasian plate. According to Italy's Institute of Geophysics and Volcanology, the earthquake shifted the Earth's axis by 25 cm which would have led to a shortening of the 24-hour day by 1.8 microseconds.

(iv) Anthropogenic

Human over-interaction with nature is also one of the main causes of earthquakes. The extraction of minerals, deep underground mining, blasting of rocks by dynamites for construction of roads, dams and reservoirs, nuclear explosions, etc. lead to the occurrence of earthquakes of various intensity and magnitude. The Koyna earthquake of 1967 in Satara district of Maharashtra was mainly due to Koyna Reservoir constructed in 1962. There have been earthquakes due to the construction of Hoover Dam (1935), Mangla Dam (Pakistan), Kariba Dam (Zambia), Manuic Dam (Canada), Kurobe Dam (Japan), Nourek Dam (Russia) and Marathon Dam earthquake-1931 (Greece). Some of the largest killer earthquakes have been plotted in **Fig. 2.25**.

Table 2.2: *Some of the important earthquakes of the world.*

Year	*Date*	*Location*	*Deaths*	*Magnitude*
1556	Jan.23	Shenshi, China	830,000	-
1737	Oct.11	Kolkata, India	300,000	-
1923	Sept.1	Kwanto, Japan	143,000	8.2
1939	Dec.27	Erzican, Turkey	40,000	8.6
1970	May 31	Northern Peru	66,000	7.8
1976	July 288	Tangshan, China	250,000	7.6
1978	Sept. 16	Iran	25,000	7.7
2004	Jan.26	Banda Aceh, Sumatra, Indonesia	> 200,000	8.5
2011	March, 11	Tohoku, Japan	>25,000	9.0

Source: 1. *Christopherson, R.W., 1995,* **Elemental Geosystem – A Foundation in Physical Geography,** *Prentice Hall, Englewood Cliffs, New Jersey-07632, p. 298.*

2. *Frontline, Vol-28, N.7, March 26, 2011, pp.8-14.*

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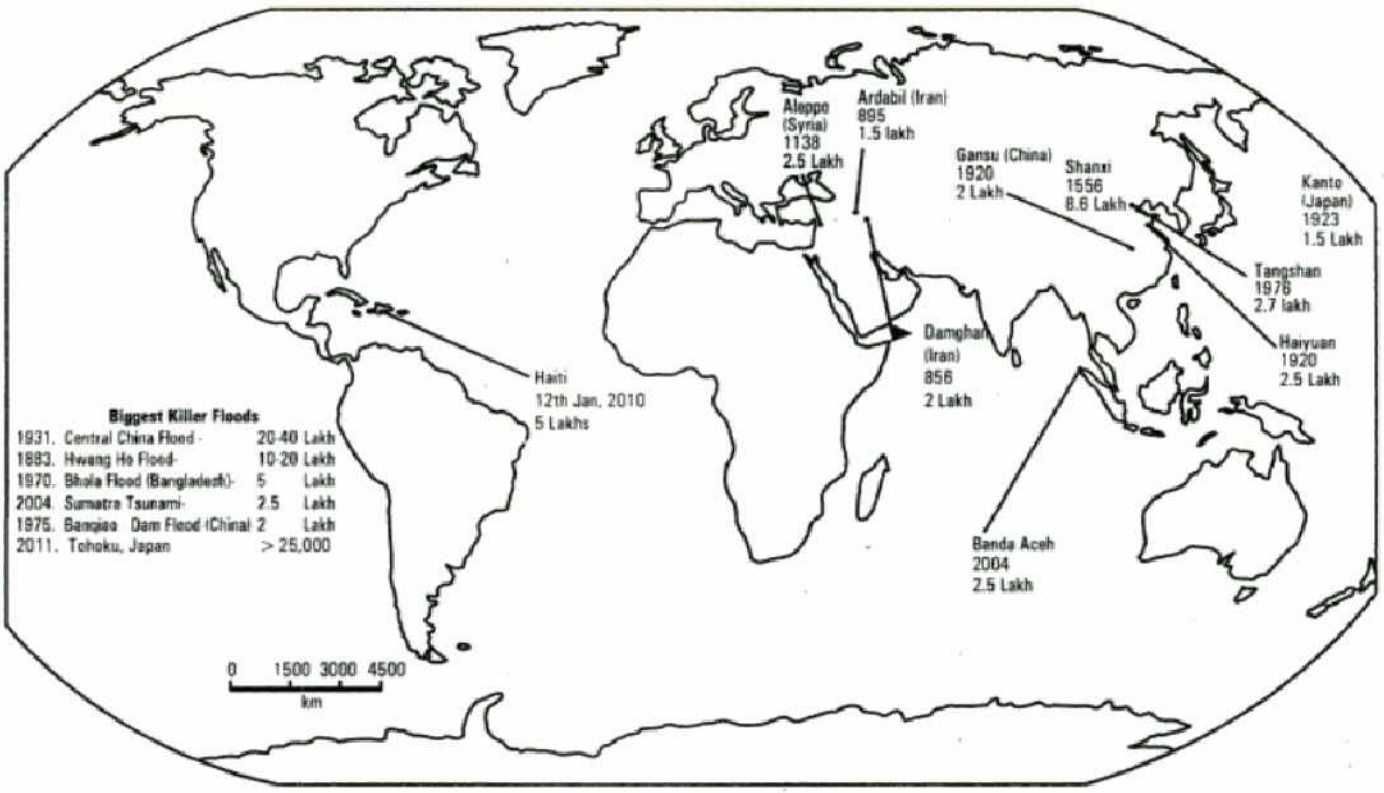

Fig. 2.25 – Largest killer earthquakes (Epicentres, Years and Casualties)

Earthquake Zones of India

In India, most of the earthquakes occur in the Himalayan belt. The young folded Himalayan belt is a marked region of instability which is characterised with several thrust planes. The Indo-Gangetic alluvial track, the Rann of Kachchh are also highly vulnerable to earthquakes. The peninsular part is considered to be a more stable block. Occasionally, some earthquakes are felt along the margins. The Koyna earthquake of 1967 and the Latur earthquake of 1993 show that the peninsular India is also not a earthquake free zone of the country. The earthquake zones of India have been shown in **Fig. 2.26**.

Consequences of Earthquakes

Throughout the human history, earthquakes have done great damage to human lives and property. The major consequences of earthquakes are: (i) deformation of ground surface, (ii) loss of human life and livestock, (iii) damage and destruction of human establishments, structures, buildings, railway-lines, roads, bridges, dams, villages, towns and cities, (iv) tsunamis (seismic sea-waves), (v) rise and subsidence of ground surface, (vi) devastating fires, flash-floods, landslides, changes in the underground water level, and 'meltdown' of civil nuclear reactors like the Fukushima Daiichi plant in Japan, (March, 2011). This earthquake shifted the Honshu island by 2.4 metres.

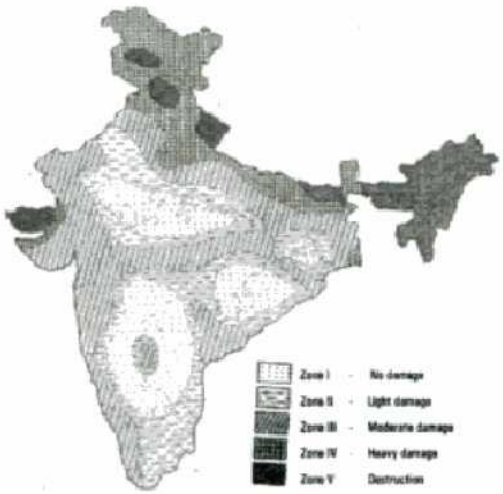

Fig. 2.26 – India – Earthquake prone zones

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Earthquake Forecasting

Till date scientific prediction about earthquakes has not been possible. Therefore, implementation of an action plan to reduce deaths, injuries, and property damage from earthquakes is very difficult. The political environment adds complexity; sadly, the impact of an accurate earthquake prediction may be viewed as a negative threat to a region's economy. For example, if the seismologists examine the potential socio-economic impact of earthquake prediction on an urban community, it is difficult to imagine a chamber of commerce, bank, real-estate agent, tax assessor, or politician who would privately welcome such prediction.

The Chinese, on the basis of seismographic studies on animal behaviour, made fairly accurate predictions about the Haicheng (China) earthquake in 1975. The Chinese seismologists provided a list of indicatives of animal behaviour. Before the earthquake of Haicheng e.g. cattle refusing to enter houses, corals and ducks refusing to enter water, snakes coming out of hibernation and fish jumping out of water. Chicken, mules, goldfish, mice, all showed unusual behaviour just before the earthquake. The water of the wells rose by more than one meter, the dogs started barking and running for shelter inside the house, while, the livestock was restless. On the basis of these indicators, a reliable prediction was made and thus, lives of thousands of people was saved. The very next year in1976, the Tangshan earthquake could not be predicted in which more than 2.5 lakh people lost their lives. Despite animals behaviour, precise, scientific predictions about earthquakes is still a remote possibility.

Denudation

The combined action of all of the processes that cause the wearing away and lowering of the land, including weathering, mass wasting, and work of agents of erosion (running water, wind, glaciers, sea-waves and underground water) is known as denudation.

Weathering

The processes by which rocks are chemically decomposed or physically disintegrated into fragments as a result of exposure to atmospheric agents and the pressures and temperatures at or near the Earth's surface, with little or no transportation of the loosened or altered materials. Weathering is a process that affects rocks *in-situ* in which no transportation is involved. Thus, weathering is essentially the break-down of rocks due to physical (mechanical) and chemical processes at their places.

Weathering is a critical base to our ecology, and our existence depends on it. Weathering produces soil on which agriculture depends. Sand gravel, and clay deposits are produced by weathering. Practically all aluminium ore, tin, and some copper ore are formed and concentrated by weathering.

The weathering of a rock is influenced by a number of factors, such as: (i) rock structure and hardness, (ii) climate, (iii) topography and slope, (iv) type of natural vegetation, (v) time, and (vi) land use by man **(Fig. 2.27)**.

Weathering may be classified under the following three categories:

(i) Physical or mechanical weathering
(ii) Chemical weathering, and
(iii) Biological or organic weathering

(i) Physical Weathering

Physical weathering is also known as mechanical weathering. When rock is broken *in-situ* and disintegrated without any chemical change, the process is called as physical weathering. For example, the break up of massive rock (bed-rock) into small particles through the action of frost or /and change in temperature – leading to expansion and contraction of rocks, salt crystals, crystallisation, hydration, and the action of plant roots penetration into cracks in rocks. The physical weathering is mainly found in the higher latitudes and higher altitudes **(Fig. 2.28)**.

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Frost action

Water expands as much as 9 % of its volume as it freezes. This expansion creates a powerful mechanical force called frost action or freeze-thaw action. Frost actions are important in humid micro-thermal climates, and in sub-arctic, polar and high altitudinal climates.

Crystallisation

Crystallisation is a phenomenon in the arid and semi-arid climates. Dry weather draws moisture to the surface of rocks. As the water evaporates, crystals form from dissolved minerals. As the process continues over time and the crystal grow and enlarge, they exert a force great enough to spread part individual mineral grains and begin breaking up the rock.

Hydration

This is a physical weathering process. Hydration is a process involving water, although not involving any chemical change; water is added to a mineral, which initiates swelling and stress within the rock, mechanically forcing grains apart as the constituents expand.

Exfoliation

Exfoliation is a physical weathering process by which concentric shells, slabs, sheets, or flakes are successively broken loose and stripped away from a rock mass. This is also known as *onion weathering*. Exfoliation process creates arch-shaped and dome-shaped features on the exposed landscape, forming an exfoliation dome **(Fig. 2.28)**.

(ii) Chemical weathering

Chemical weathering is brought about by the action of substances dissolved in rain-water. They are usually acidic in character and leach rock quite actively. In general chemical weathering is more important than physical weathering. This is particularly so in the hot and humid climates of the equatorial, monsoon and other sub-tropical wet regions. The chemical weathering is more pronounced in the regions of *karst* topography and limestone regions. The main processes of chemical weathering are: oxidation, carbonation, solution, and hydrolysis.

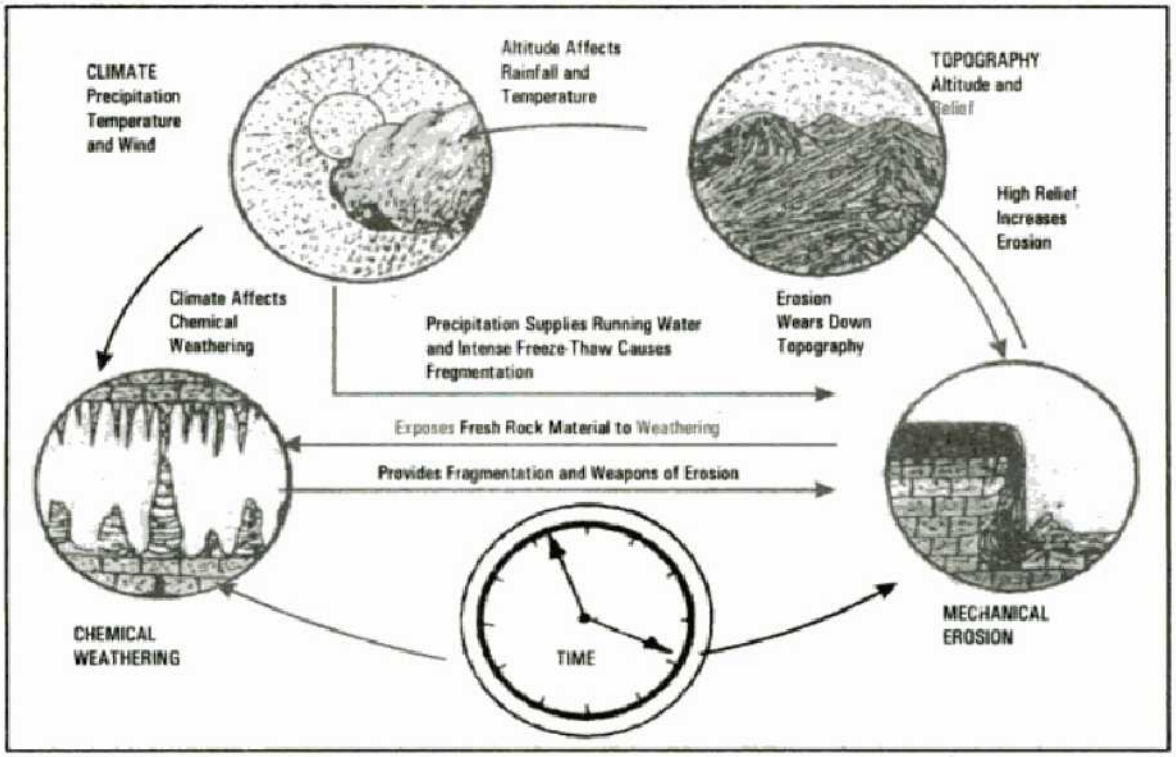

Fig. 2.27 – Major determinants of Weathering (after A.H.Strahler)

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Oxidation

Chemical combination of oxygen with another substance is known as oxidation. The most familiar is the *'rusting'* of iron-ore in rocks or soil that produces a reddish-brown stain of oxide. Thus, the iron bearing rocks become weak by the process of oxidation.

Carbonation

This is a process of chemical weathering by a weak carbonic acid (water and carbon dioxide) that reacts with many minerals, especially limestone containing calcium, magnesium, potassium, and sodium transforming them into carbonates.

Hydrolysis

When minerals chemically combine with water, the process is called hydrolysis.

Solution

The change of limestone from the solid state to the liquid state by combination with water is known as solution.

Biological or Organic Weathering

It is the disintegration or destruction of a rock by living organisms or organic processes. It is a much neglected cause of weathering. For example, algae, mosses, lichen and other vegetations retain water on the surface of the rock, and various organic acids help to decay the rock beneath, so that a tuft of moss may lie in a small and growing hollow in the rock. The presence of vegetation increases the acid content of the soil water, which helps in the chemical disintegration of calcarious rocks. The water containing bacteria can help the composition of some rocks, particularly limestone. The mechanical disintegration effect of vegetation is mainly due to the penetrating and expanding of roots.

Various forms of life, such as worms, rabbits and moles also disintegrate rocks. Worms bring large quantities of fine material to the surface in the form of casts, while borrowing animals help to loosen the surface material.

Erosion

Denudation by running water, wind, ice (glacier), underground water and sea-waves is known as erosion. In other words, the processes that loosen sediment and move it from one place to another on the Earth's surface is known as erosion. Running water, as stated above, is the most powerful land forming agent. The action of running water known as fluvial action can be observed everywhere on the Earth's surface.

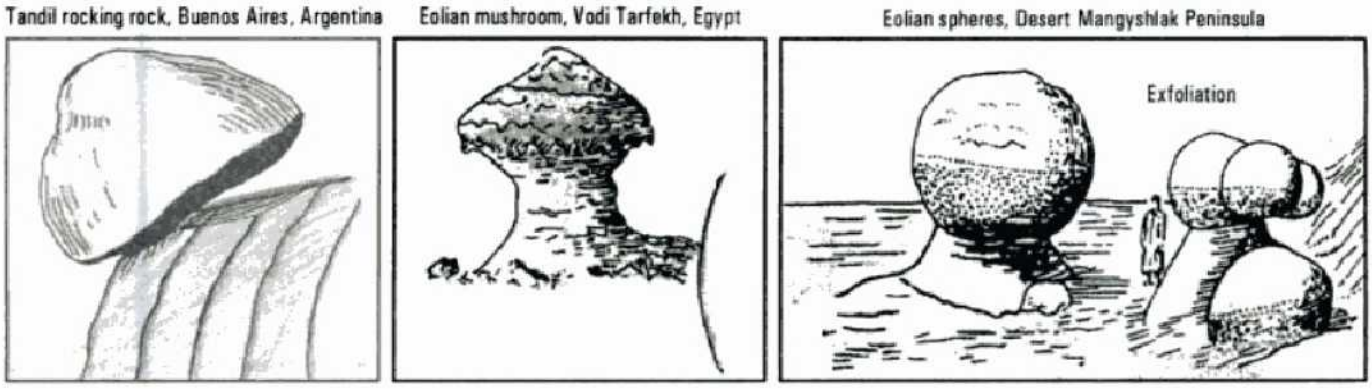
Tandil rocking rock, Buenos Aires, Argentina
Eolian mushroom, Vodi Tarfekh, Egypt
Eolian spheres, Desert Mangyshlak Peninsula
Exfoliation

Fig. 2.28 – Physical weathering

Fluvial Processes (Rivers and Related Landform)

Rivers have often been described as the life blood of the Earth. They redistribute mineral nutrients which are important for soil formation and plant growth and serve society in many ways. Rivers provide essential water supplies for domestic, agricultural, industrial use and transport. Rivers have been of

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fundamental importance throughout human history. A brief account of the river action and the consequent landforms have been given in the following.

Running water (river) by far is the most important agent of erosion. Other agents of erosion such as glaciers, wind, underground-water and sea-waves are locally dominant which affect limited parts of the Earth's surface.

River System

A river system is a network of connecting channels through which water of rainfall is collected and carried to the ocean **(Fig. 2.29)**. A river system may be divided into three parts: (i) collection system, (ii) transport system, and (iii) depositional or dispersing system **(Fig. 2.30)**.

The erosion capacity of a river depends on (a) discharge, (b) velocity, (c) gradient slope, (d) sediment load, and (e) base level.

The main functions of a river are: (i) removing of regolith (weathered material), (ii) down cutting, (iii) headward cutting (erosion), and (iv) deposition.

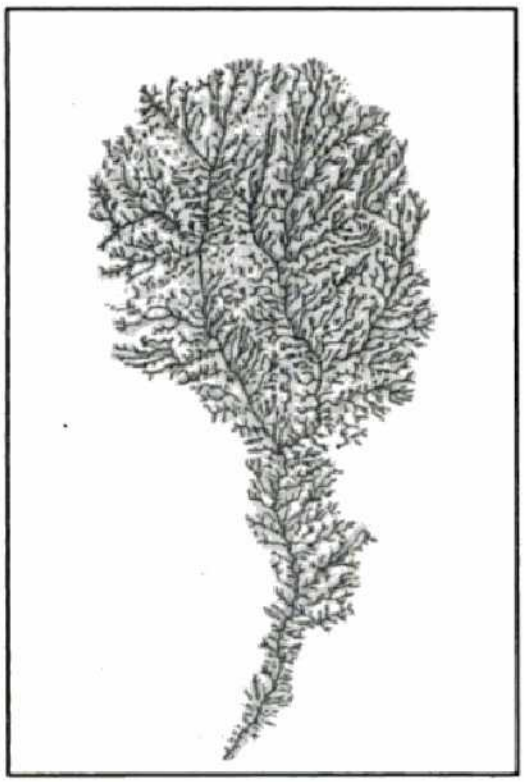

Fig. 2.29. – A river system is highly complex (after W.K. Hamblin *et. al.*)

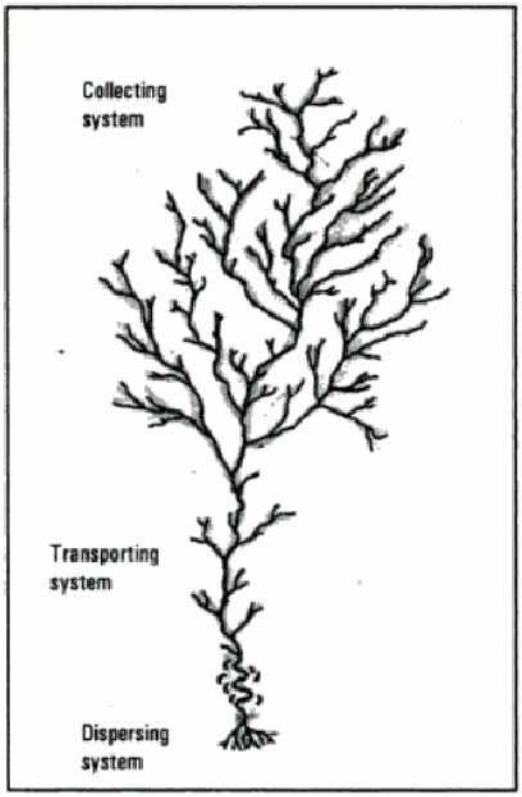

Fig. 2.30 – Major parts of a river system (after W.K.Hamblin, *et.al.*)

Erosion by Running Water

Running water erodes the rocks either by chemical or mechanical method. Some of the rocks (limestone, gypsum, etc.) over which the water flows, are dissolved in water. This process of dissolution is known as *chemical erosion*. The mechanical erosion is caused by loose solid material carried down by river, in wearing away fragments from its beds and banks. Corrosion of the bed, thereby causing a deepening of the channel is called *vertical erosion*, while corrosion of banks is known as *lateral erosion* **(Fig. 2.31)**. Most of the corrosion by a river, however, is due to pebbles, gravels and sand that drives along its banks. Thus in a

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fluvial process, mechanical erosion is more important than chemical erosion. The rock fragments also collide against one another and in the process get disintegrated into small, smooth, rounded pieces of rock and ultimately into sand and silt. The process by which there is a progressive downstream reduction in size of the materials (load of a river by constant collision) is known as *attrition*.

Stream Transportation

The solid material carried by a stream is the stream load. The running water and all streams carry some dissolved material. Sand, gravel, pebbles, shingles and boulders are carried as the bed-load close to the channel floor by rolling or sliding. Clay and silt are carried by suspension. Some soft rocks are dissolved in water and they are carried in solution. In almost all the streams, *the suspended load is the maximum*. In general, more the velocity of a river, more the load it can transport.

Stream Deposition

Stream deposition is the accumulation of transported particles on the stream bed and flood plains, or on the floor of lake or sea into which the stream empties. As the velocity of a river decreases, it begins to deposit its load of rock fragments, sand and silt. At the time of flood, the river inundates its adjacent areas and deposits sand and silt outside the confines of channel. The maximum deposition takes place in the delta region when the river enters the sea or lake.

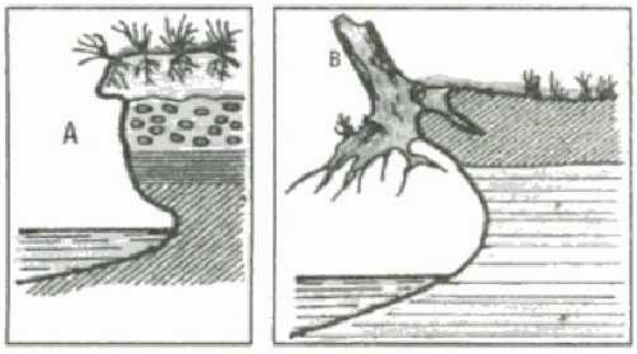

Fig. 2.31 – A. River bank eroded by current. B – Eroded - bank with tree stump and roots

Longitudinal Profile (Long Profile of a River)

The graph representing the relation between altitude and distance along the course of the river known as longitudinal profile. The profile is usually concave upwards, which is graded to the local or regional base level, and may be punctuated by knick-points where the river cuts through former valley floors or river terraces **(Fig. 2.32)**.

Cross Profile (River Channel)

A profile may be surveyed at right-angles to the river flow direction across a river channel or across the valley in which the river channel occurs. Information from contours or topographic maps is often sufficiently detailed to draw valley cross-profile **(Fig. 2.33)**.

Base Level

The lower limit to the operation of sub-aerial erosion processes, usually defined with reference to the role of running water. The level of the sea surface at any moment acts as a general base level for the continents, although there can be a wide range of local base levels, some above and some below sea level. The term was first used by J.W. Powell (1875) who defined it in a very broad fashion to include: first, the concept of the sea as 'a grand base-level, below which the dry lands cannot be eroded'; secondly, the existence of local or temporary base levels 'which are the levels of the beds of the principal streams which carry away the products of erosion; and, finally, as 'an imaginary surface, inclining slightly in all its parts towards the lower end of the principal stream draining the area'. W.M. Davis 1899/ 1902 considered that the breadth of Powell's definition had led to a variety of practices and confusion. He, therefore, proposed that base level be restricted to 'simply ... the level base with respect to which normal sub-aerial erosion proceeds' **(Fig. 2.34)**.

Base levels can be identified on a number of different scales. A stream channel acts as the base level for processes on the adjacent slope. A major stream is the base level for the courses of its tributaries. A lake or a reservoir or a waterfall is the base level for the entire basin upstream. Clearly, these base levels can and will

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alter over the time with implications for the operation of sub-aerial erosional processes. By and large, a fall in base level creates an increase in potential energy by increasing the total relief, and may result in an acceleration of rates of erosion and down cutting. A rise in base level, on the other hand, reduces relief and potential energy and its frequency marked by aggradation.

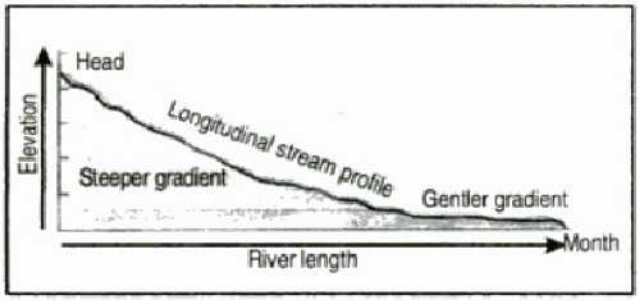

Fig. 2.32 – Idealised cross-section of the longitudinal profile of a stream showing its gradient. Upstream segments have a steeper gradient, whereas downstream the gradient is more gentle

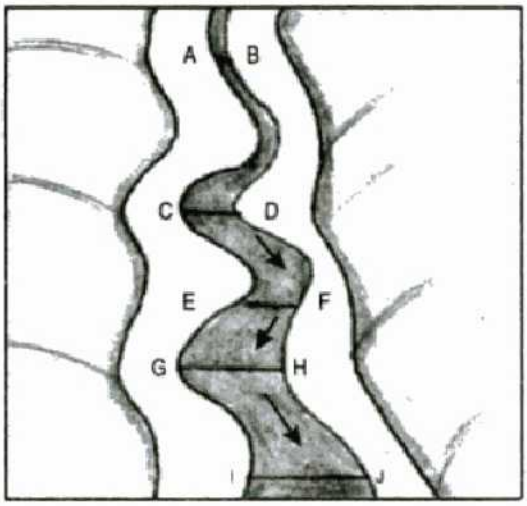

Fig. 2.33 – Cross or transverse profiles

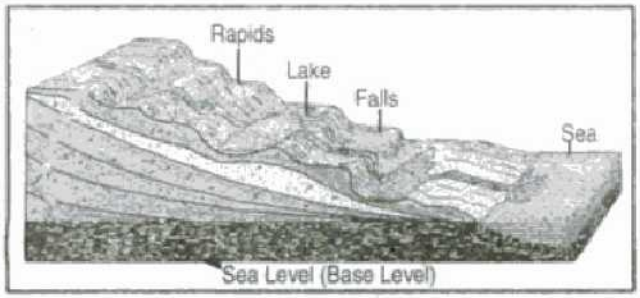

Fig. 2.34 – Base level (after W.M.Davis)

Landforms of Streams

Landforms in the Upper Course

Landforms in the upper coursa include waterfalls, cataracts, rapids, nickpoints, gorges, canyons, convex and concave slopes, river terraces, alluvial-fans (alluvial cones).

Gorge (Canyon)

It is a a deep and narrow section of river valley usually with near vertical rock walls more generally a narrow valley between hills or mountains **(Fig. 2.35)**. The Grand Canyon of the Colorado river in USA is the largest (277 km), widest (18km), and deepest (over one km) gorge in the world.

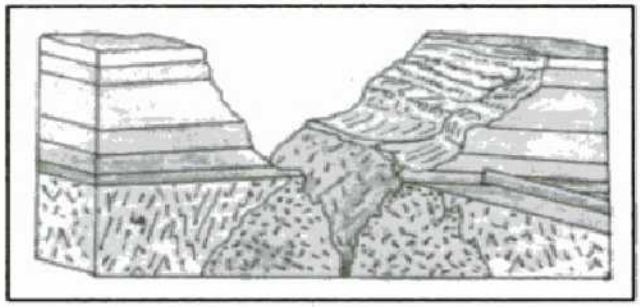

Fig. 2.35 – Gorge (canyon)

Rapids

A steep section in a river channel where the velocity of flow increases and there is extreme turbulence **(Fig. 2.36)**.

River Terrace

It is a nearly a flat area formed at river level, but now above the river, separated at least by an eroded slope. Such a landform implies that production of a valley floor or alluvial plain, by a phase of deposition or lateral erosion by the river, was followed by a phase of down-cutting. Terraces may be rock-floored or alluvial. The simple alluvial terraces consist of deposits from one phase, but often there are patches of older deposits: just as a terrace may be cut into rock, it may be cut into any previous deposit, fluvial or otherwise. Thus, the age of terrace materials must not be confused with the age of the landform **(Fig. 2.37)**.

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Waterfall

It is a stream that falls from a height. Waterfalls are often the sites of greatest concentration of energy dissipation along the course of a stream and have generally been regarded as forming where a soft rock is eroded from beneath a harder rock **(Figs. 2.36 and 2.38).**

However, in reality, waterfalls have more diverse forms than this simple model would suggest. It is likely that it is applicable only in areas with gently dipping strata. In addition to such structural control, waterfalls depend for their development on such factors as glacial over-deepening, tectonic changes and base-level changes.

Alluvial-fan

A fan-shaped deposit of sediment built by a stream where it merges into a broad valley or plain. Alluvial fans are common in the hilly areas, especially in the arid and semi-arid climates, but are not restricted to them **(Fig. 2.39).**

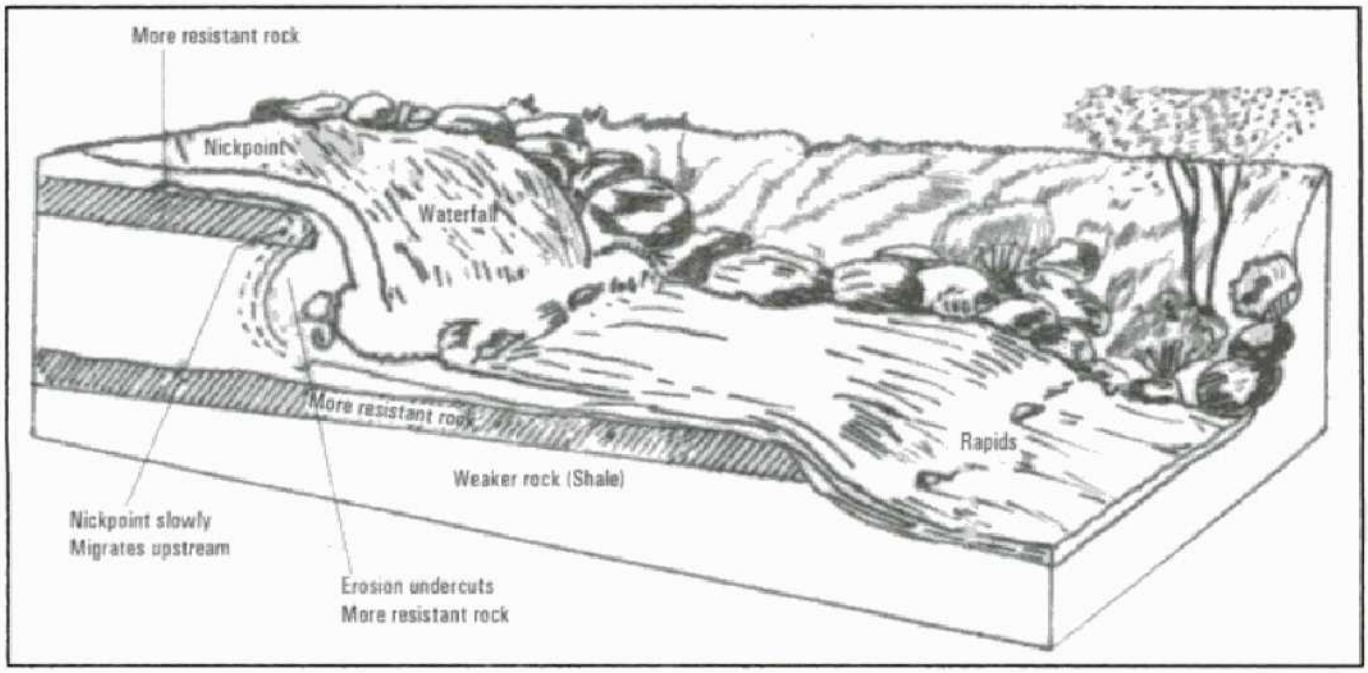

Fig. 2.36 – Rapids and waterfalls

River Capture

River capture or river-piracy occurs where a tributary with a high gradient rapidly erodes headward and captures the tributary of another river **(Fig. 2.40)**.

Landforms of Middle Course

Landforms of middle course include meanders, oxbow-lakes (bill-bong, mort-lake or bayou), natural levees, alluvial fans or alluvial cones, back-swamps, river-terraces *yazoo*-river.

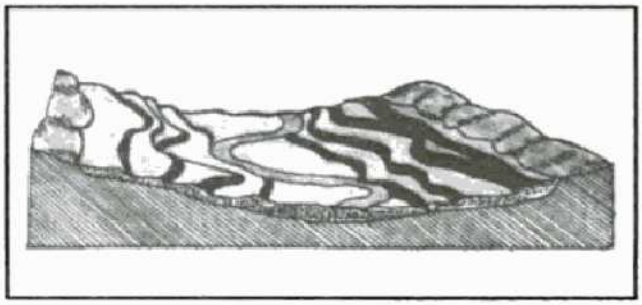

Fig. 2.37 – River terraces (after R.W.Chriastopherson)

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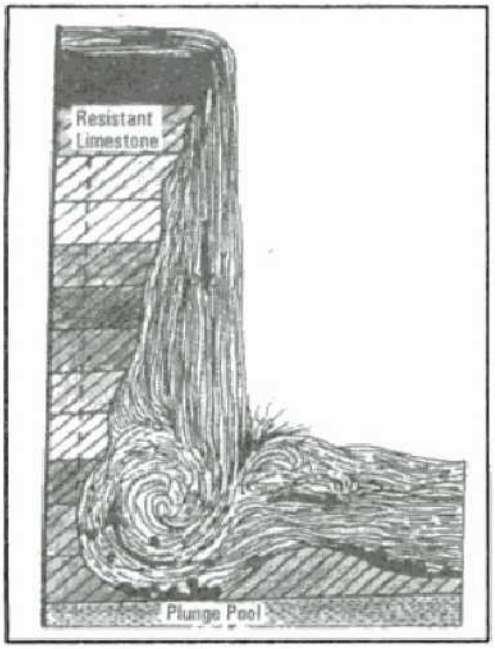

Fig. 2.38 – The Niagra fall

Fig. 2.39 – Alluvial. fan

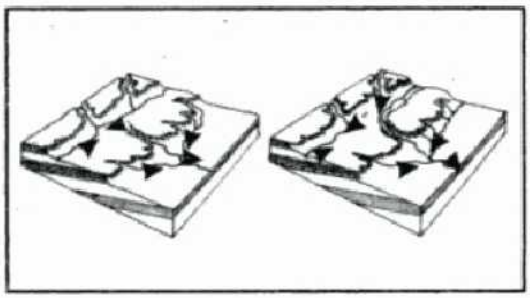

Fig. 2.40 - River capture

Flood Plain

Flood-plain is a geomorphological term for a relatively flat alluvial landform, constructed largely by the flow regime of present river and subject to flooding. Commonly plains flank a clearly defined river channel, but some occur in valleys without channels, while others form downstream of channels **(Fig. 2.41)**.

Levee

A broad, long-crested ridge running alongside a flood-plain stream or intertidal inlet, composed generally of coarse sand and silt grade suspended sediment deposited by flood waters as they overtop channel banks. The levee may slope gently away from the river and consist of progressively finer sediment as distance from the channel increases. Levees may also be artificially created or raised for flood protection **(Fig. 2.41)**.

Meander

The sinuous winding of a river, as in the *River Meanders* in south-west Turkey. A broad, looping bend in a river **(Fig. 2.42)**.

Ox-bow lake

It is a lake usually curved in plan, occupying a *cut-off* channel reach that has been abandoned. The term may be applied also to an extremely curved active channel meander with only a narrow neck between adjacent reaches or even to the land within such a reach. The term derives from the U-shaped piece of wood fitted around the neck of a harnessed ox. Lakes of this type may become plugged with sediment where they adjoin the channel and then progressively fill in **(Figs. 2.42)**

Landforms of the Lower Valley

Landforms of the lower valley include braided channel, delta, estuary and alluvial deposits.

Braided Channel (Braided River)

A river whose flow passes through a number of interlaced branches that divide and rejoin. The term has been applied both to short reaches where a river splits around an island and to very extensive river networks on valley bottoms or alluvial plains, the whole of which may be criss-crossed by rapidly shifting channels with freshly deposited sediment between them **(Fig. 2.43)**.

Delta

A large roughly triangular body of sediment deposited at the mouth of a river. The different types of deltas have been given in **Fig. 2.44**.

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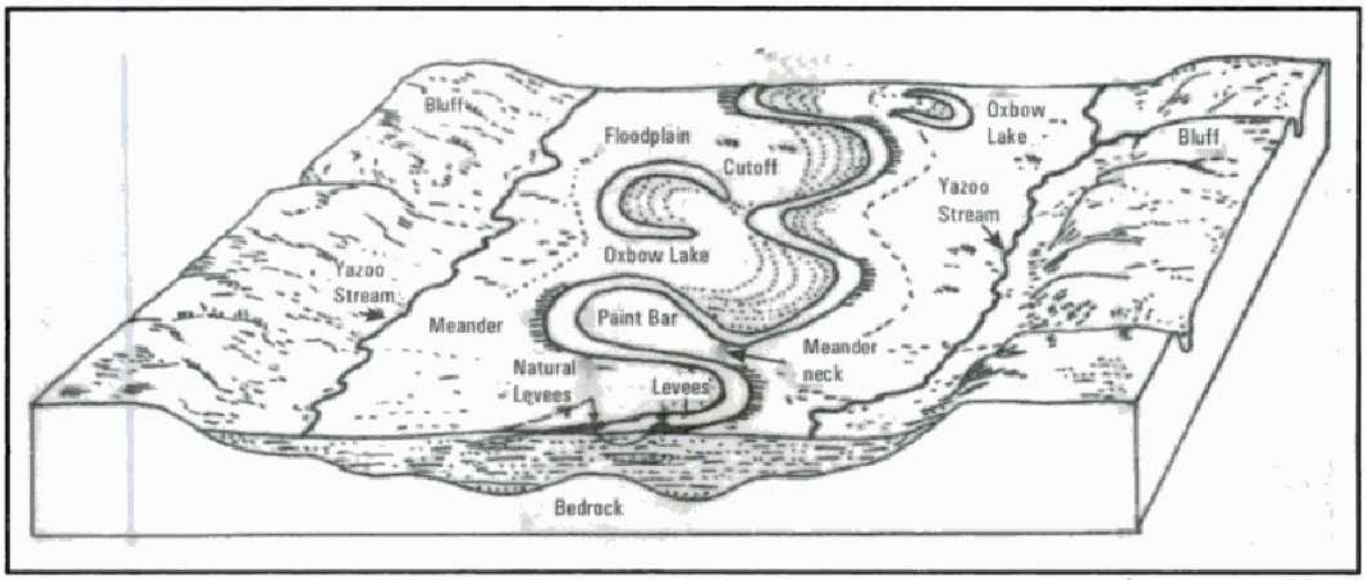

Fig. 2.41 – Major features of floodplain – Meanders, point-bars, ox-bow lakes, natural levees, stream-channels and Yazoo-stream

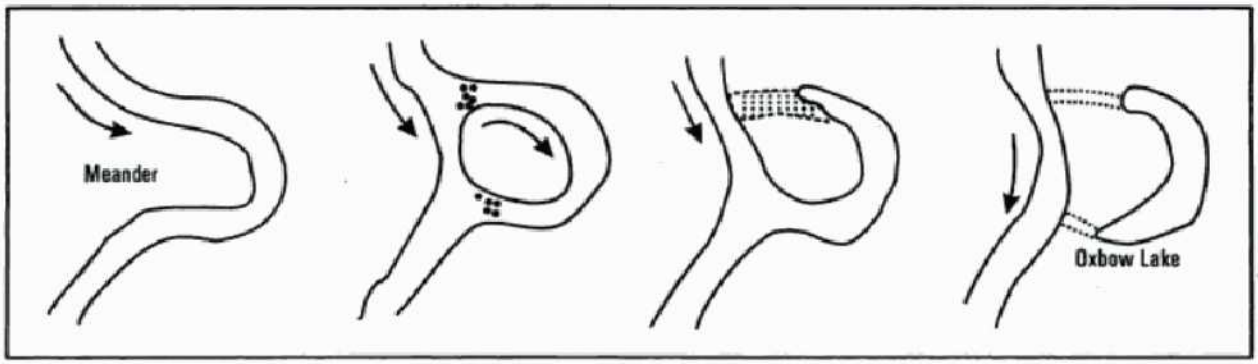

Fig. 2.42 – Transformation of Meander into Ox-bow lake

Estuary

The point at which the mouth of a river enters the sea and seawater are mixed, a place where tides ebb and flow **(Fig. 2.45).** The Narmada and Tapti rivers make estuaries in the Gulf of Khambat.

Alluvial Deposits

The various types of alluvial deposits are: Colluvial deposits, vertical accretion deposits, lateral accretion deposits, filled channels, alluvial fans, etc. **(Fig. 2.46).**

(ii) Glaciers and Glacial Landforms

A mass of ice formed from compacted, recrystallised snow that is thick enough to flow plastically is known as a glacier. Glaciers at present cover about 15 million sq km or about 10 per cent of the land area of the Earth. Over 96 per cent of the glacier ice, however, occurs in Antarctica and Greenland in the form of thick masses of ice-sheet. The greatest thickness of ice measured is 4270 metres (Antarctica).

Glaciers are formed due to accumulation of ice above snow-line. The altitude which delimits the lower level of permanent snow is known as snow-line. The snowline varies according to latitudes, altitudes and the degree continentality. A glacial system has been shown in **Fig. 2.47**, while **Fig. 2.48** represents the longitudinal profile of a valley glacier.

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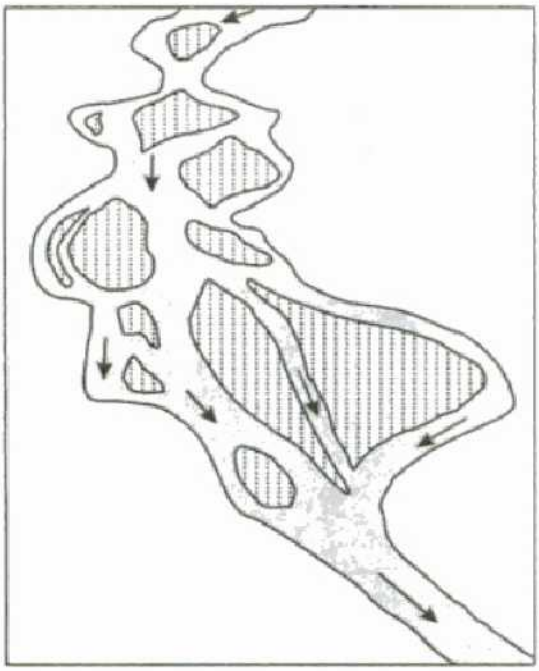

Fig. 2.43. – A braided stream

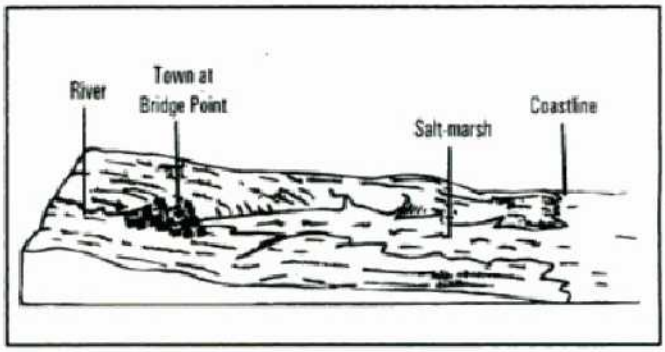

Fig. 2.45 – Estuary

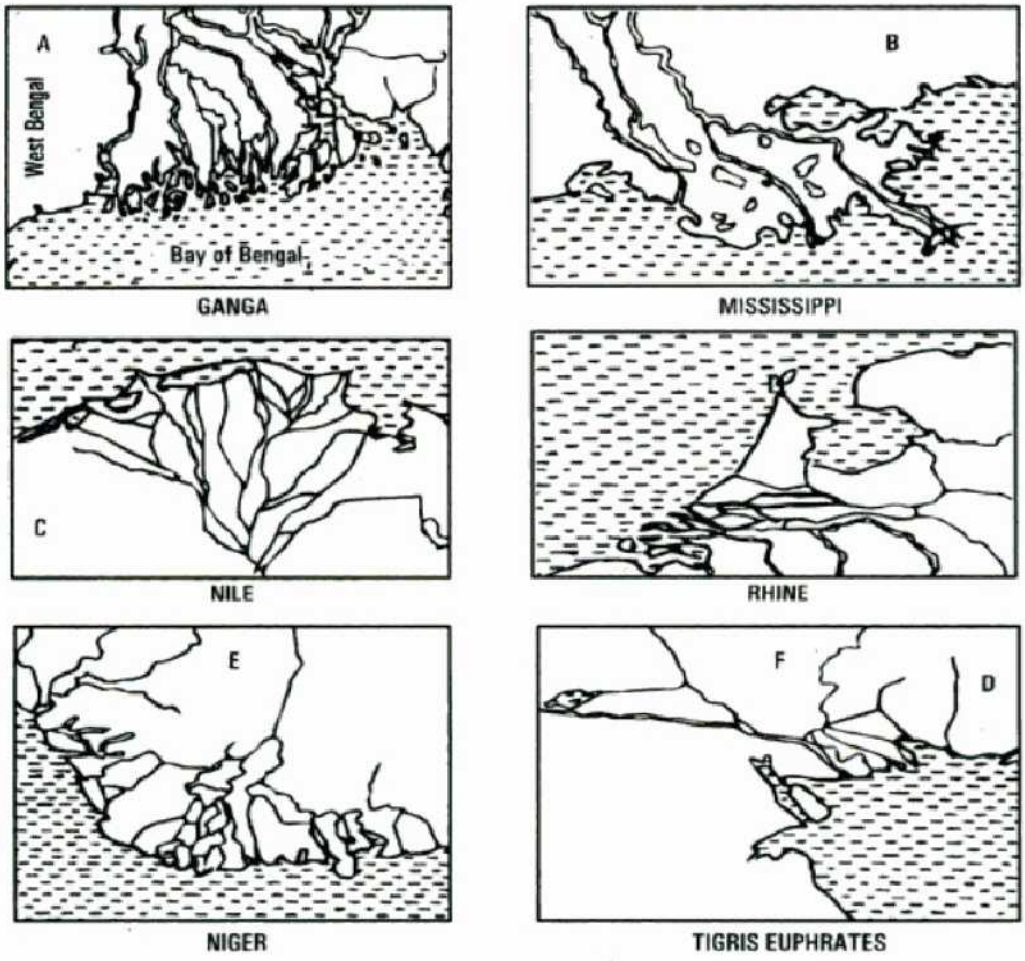

Fig. 2.44 - Some of the great deltas of the world

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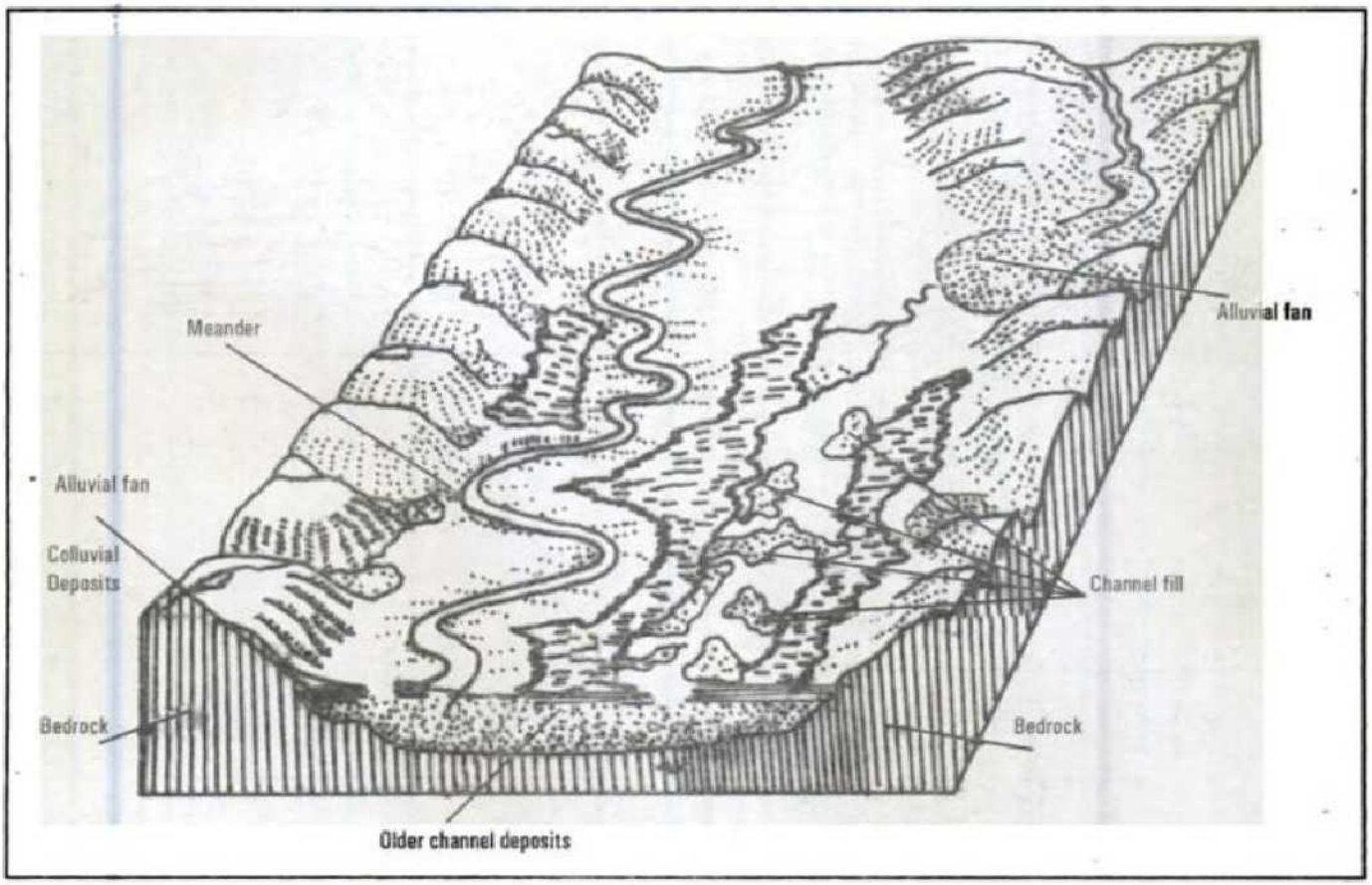

Fig. 2.46 – Types of alluvial deposits

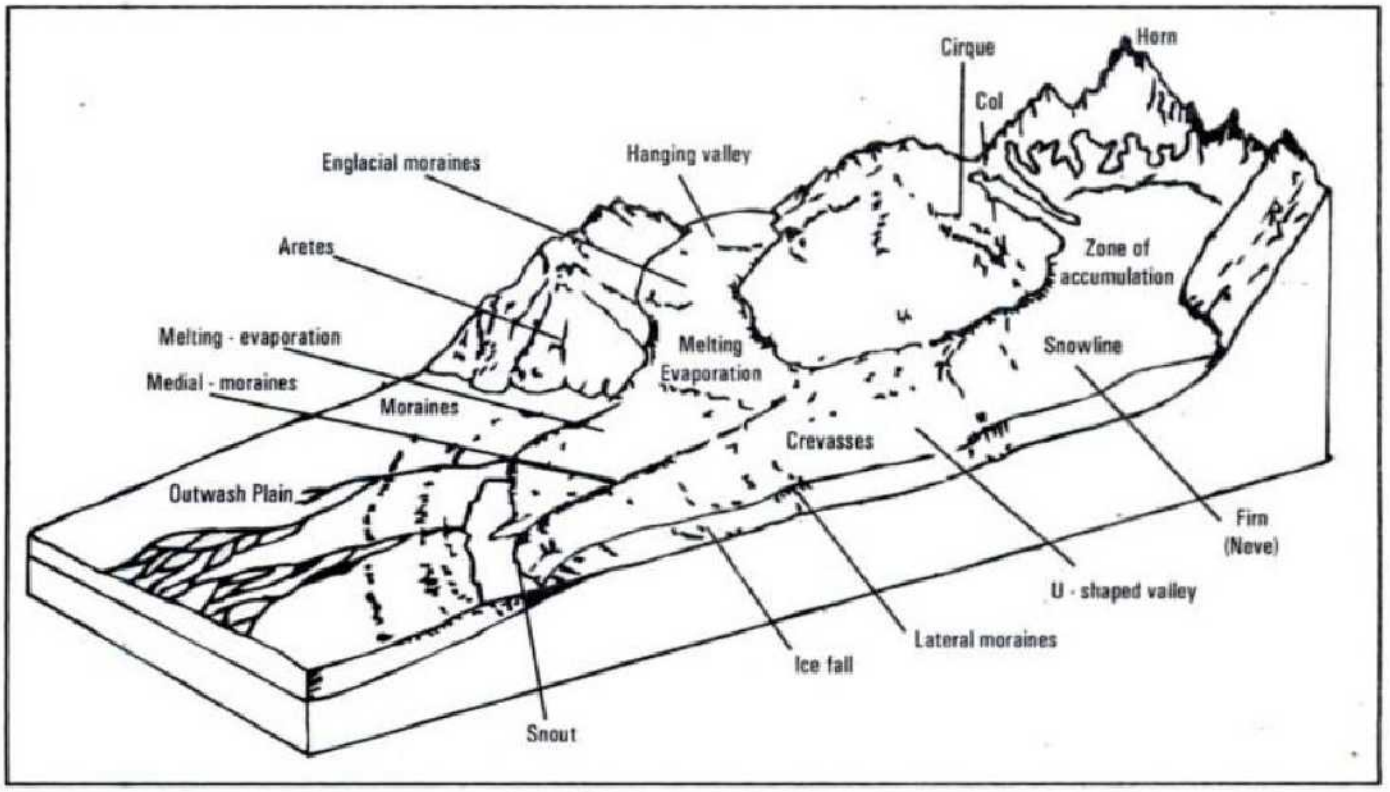

Fig. 2.47 – A glacial system

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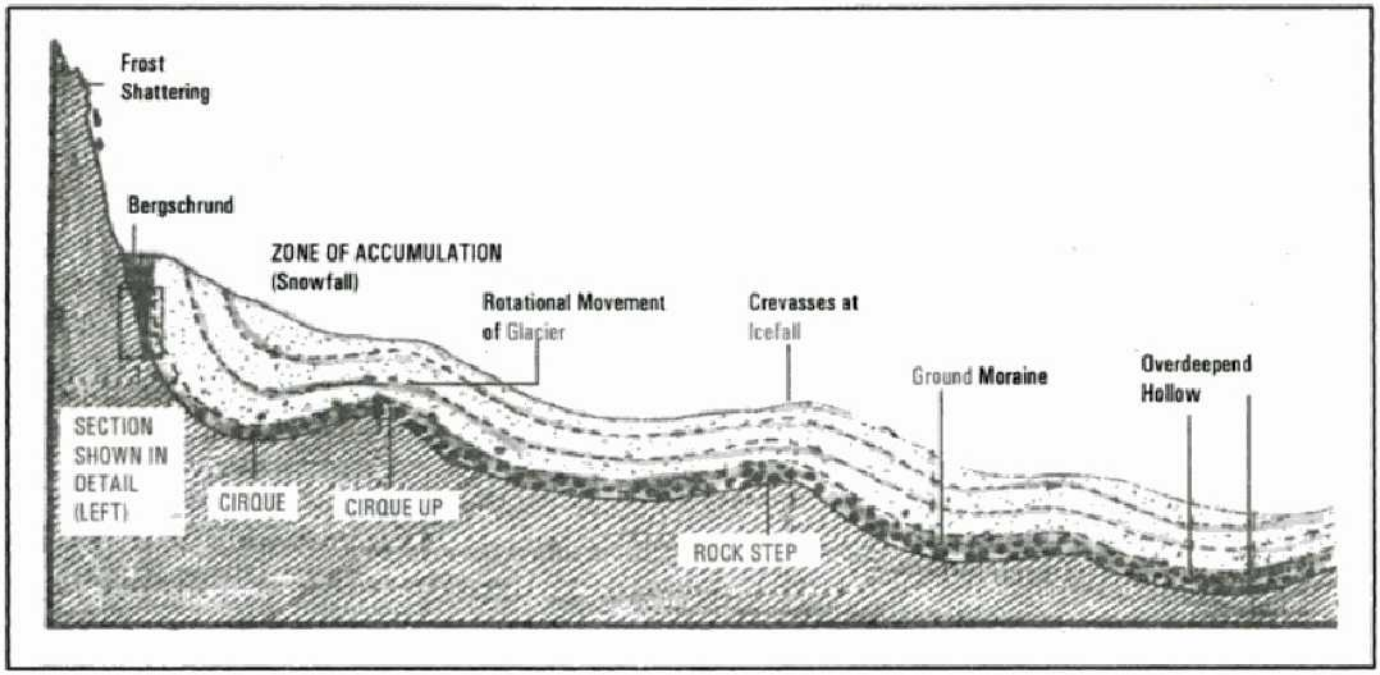

Fig. 2.48 – Longitudinal profile of a glacier

Types of Glaciers

Glaciers, in general, are two types:

Continental glaciers

Ice-sheet is a large continuous layer of land ice of considerable thickness. The average thickness of Antarctic ice-sheet is 2000 m which covers an area of 8 million sq km. The Greenland continental glacier has a thickness of 3000 m at its central dome and sprawls over an area of 1.3 million sq km.

Valley or Mountain Glaciers

Valley glaciers are the characteristic features of the greater mountain ranges of the world. The valley glaciers are mostly confined in the young folded mountains, like the Himalayas, Rockies, Andes, Alps, etc. Some of the important landforms created by the erosion and deposition processes of glaciers are as under:

Erosional Landforms

Cirque (Cwm, Welsh), arêtes, bergschrund, Col, Crag and tail, Fiord, Hanging Valley, Horn, Icefall, Neve, Niche, Nunataks, Pinnacle (Serac), Rochess Moutonnees, U-shaped valley.

- ***Arteries***

  A sharp ridge that separates two adjacent glacial valleys. Arete means'fish-bone' in French. Aretes form sawtooth and serrated ridges in glaciated mountains **(Fig. 2.47)**.

- ***Bergschrund***

  A deep, tensional crevasse formed around the head of a cirque glacier. The crevasse forms as ice falls away downslope. Often a sequence of bergschrunds form **(Fig. 2.48)**.

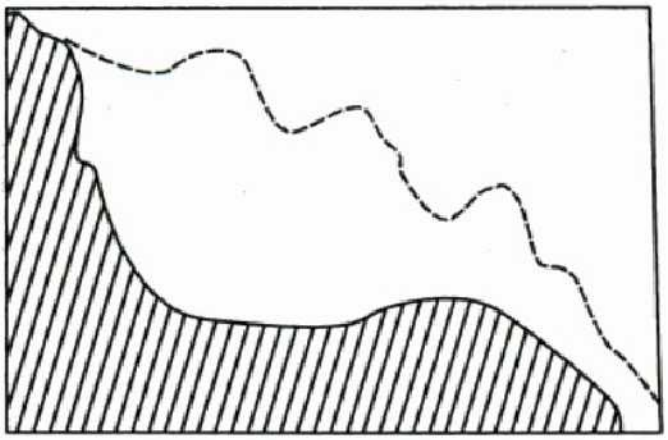

Fig. 2.49 – Longitudinal section of a cirque (corrie)

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- ***Cirque (Cwm)***

  An amphitheatre-shaped depression at the head of a glacial valley, excavated mainly by ice-plucking and frost wedging **(Figs. 2.49)**.

- ***Col (Saddle)***

  A pass or saddle between two mountain peaks.

- ***Crag and Tail***

  Landform consisting of a small rock hill and tapering ridge which is produced by selective erosion and deposition beneath an ice-sheet. They range in scale from tens of metres to kilometers in length, with the tail pointing in the down-ice direction. The hill, or crag, is usually of strong rock that has resisted glacial erosion and forms an obstruction to the ice-producing a 'pressure shadow' in its lee **(Fig. 2.50)**.

- ***Firn***

  The term generally applied to snow which has survived a summer melt season and which has not yet become glacier ice.

- ***Fiord or fjord***

  A long, narrow arm of the sea which is the result of the 'drowning' of a glaciated valley. Most fiords, including the fiord coastline of Norway, are located on the west coast of continental masses, and it is thought that this is connected with the westerly winds which prevail in these locations. Fiords are distinctive both because of their great depth, and because of over-deepening of their middle section which are deeper than the water at the mouth **(Fig. 2.51)**.

- ***Hanging Valley***

  A tributary valley whose floor is discordant with the floor of the main valley. Hanging valleys are a hallmark of glacial erosion in mountains.

- ***Horn-glacial***

  A pyramidal peak with three or more distinct faces steepened by glacial undercutting. The classic situation occurs when cirque glaciers encroach on a mountain from all sides.

- ***Icefall***

  A heavily crevassed area of a glacier associated with flow down a steep rock slope. The zone is one of extending flow and is marked by arcuate rotational slumps.

- ***Neve***

  A less widely used term for firn.

- ***Nunataks***

  An inuit-derived word describing a mountain/peak completely surrounded by glacier ice, normally an ice-cap or ice-sheet. In other words, a mountain peak which projects above an ice-sheet. Nunataks are generally angular and jagged due to freeze –thaw and, after the ice has retreated. Contrast with the rounded contours of the glaciated landscape below **(Fig. 2.52)**.

- ***Roche Moutonnee***

  An asymmetric rock bump with one side ice-muddled and the other side steepened and often cliffed, generally recognised as the hall mark of glacial erosion.

- ***Snout (Tung)***

  The terminus of a glacier **(Fig. 2.53)**.

- ***Tarn***

  A small mountain lake created by glacial action.

- ***U-Shaped Valley***

  A glacial valley.

Depositional Landforms

Moraines, terminal moraines, lateral moraines, ground moraines, medial moraines, englacial, drumlins, eskers, kame, outwash plain (*sandar, sandur*) **(Fig. 2.54)**.

- ***Drumlins***

  An oval-shaped mound, largely composed of glacial drift, formed beneath a glacier or

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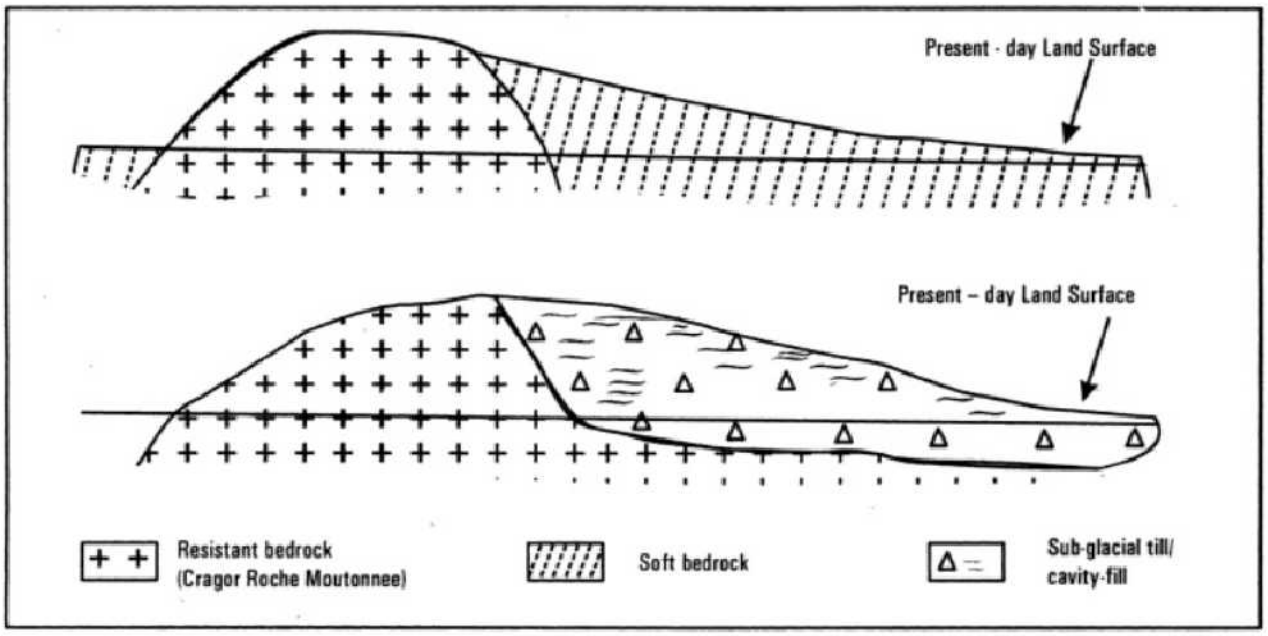

Fig. 2.50 – Crag and tail (Source: Born and Evans 1998)

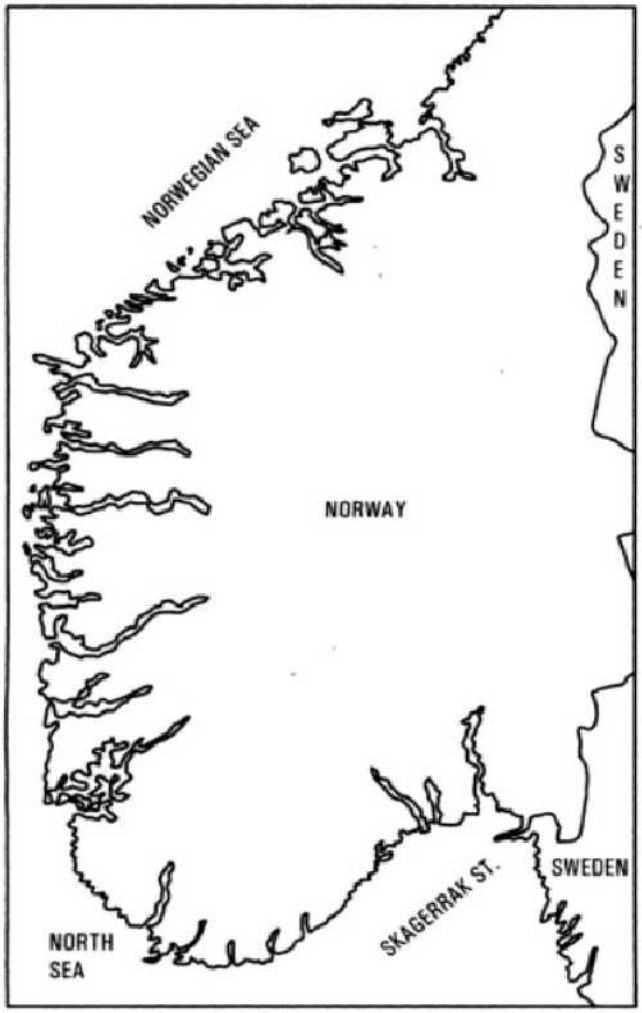

Fig. 2.51 – Fiord/Fjord

ice-sheet and aligned in the direction of ice flow. There are no strict definitions relating to their size but they tend to be up to a kilometer long and 50 metre in relief. They are widespread in Canada, Ireland, Sweden, Norway and Finland **(Fig. 2.54)**.

- ***Esker***

  A sinuous ridge of coarse gravel representing the deposits of a meltwater stream normally flowing subglacially. Eskers may be hundreds of kilometers in length and 100 m in height. Most eskers are the channel deposits of subglacial meltwater rivers and their orientation is usually parallel to that of overall ice flow **(Fig. 2.54)**.

- ***Kame***

  An irregular mound of stratified sediment associated with glaciofluvial activity during ice-stagnation. It is Scottish term for a landform much prized for the variety it adds to golf courses **(Fig. 2.54)**.

- ***Moraines***

  Any landform directly deposited by a glacier or ice sheet. The material which makes up moraines is often partly

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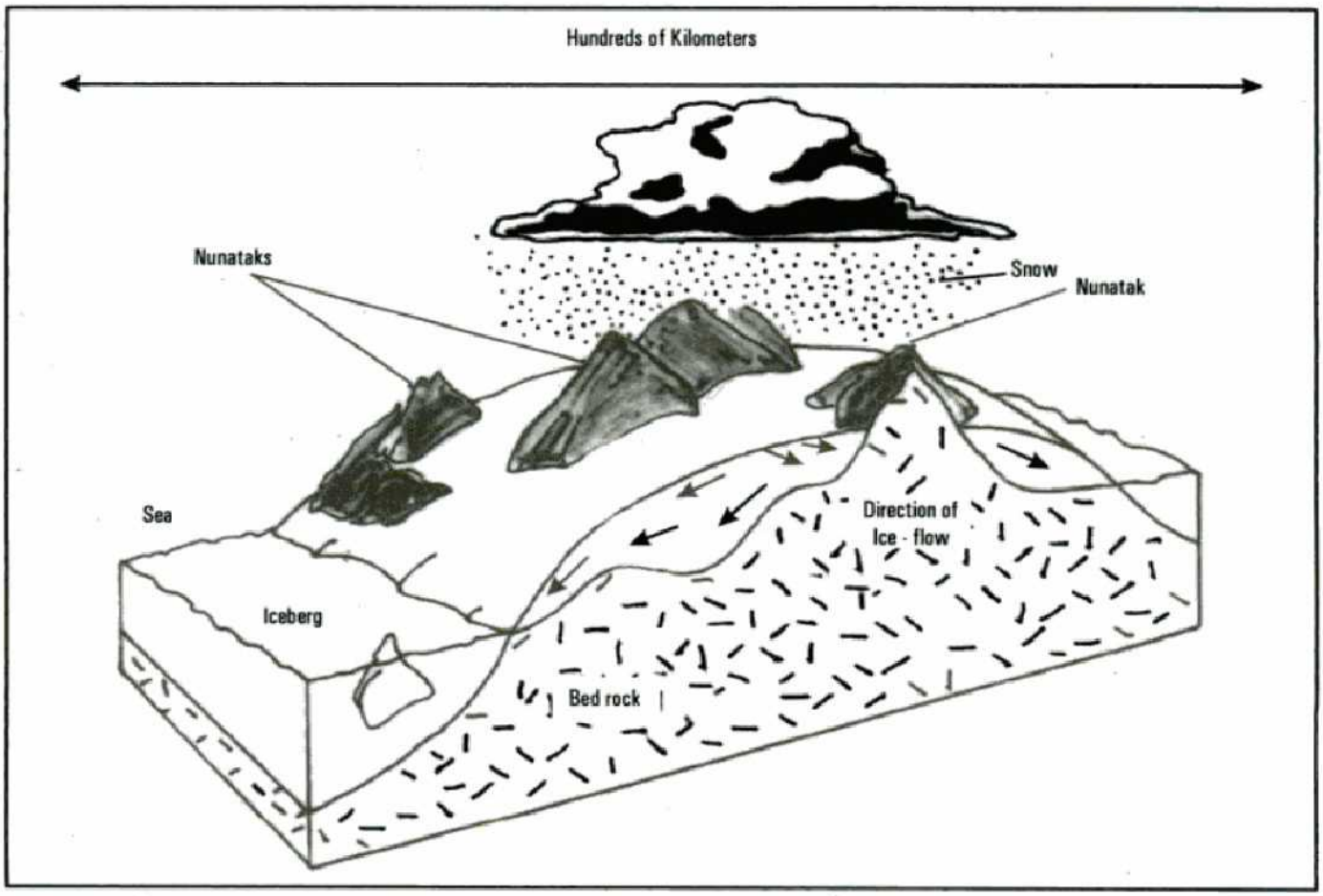

Fig. 2.52 – Ice movement in valley and continental glaciers

stratified, since some may have been formed under water. Moraines may be englacial moraines, ground-moraines, lateral moraines, or terminal moraines.

- ***Outwash Plain***

  It is a glacial plain deposited at or beyond the ice margin. Outwash usually forms fan, valley bottom or plain (*sandur*) deposits, often hundreds of metres thick, built up by aggrading braided melt water channels which migrate laterally across the outwash surface **(Fig. 2.54)**.

- ***Sandur (Sandar or Sandur)***

  An extensive plain of glaciofluvial sands and gravels deposited in front of an ice margin by a system of braided meltwater stream which migrate across the sandur surface.

- ***Till***

  A Scottish word, popularly used to describe a coarse, bouldry soil. It is a sedimentary material deposited directly by the action of a glacier **(Fig. 2.54).**

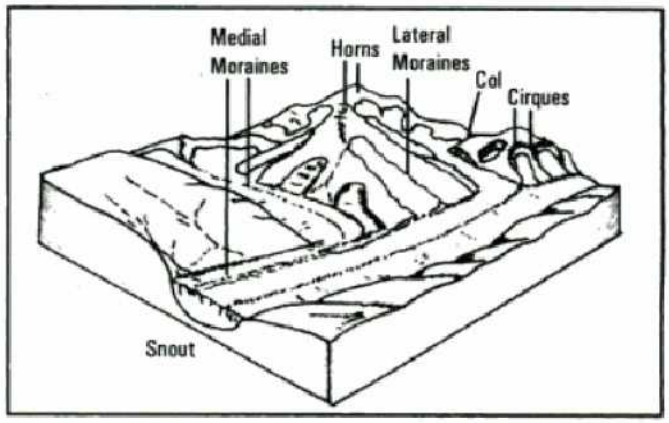

Fig. 2.53 – Snout (Tung) of a glacier

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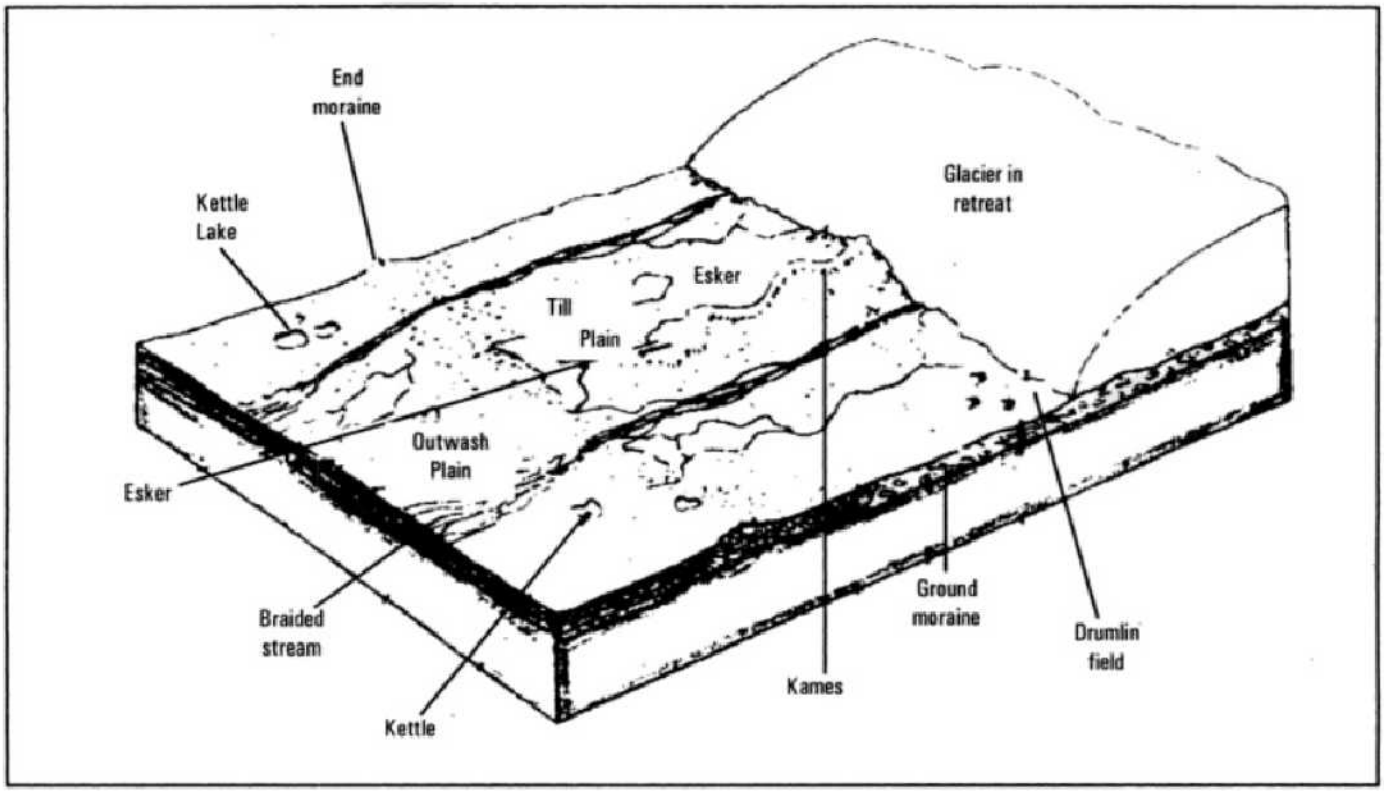

Fig. 2.54 – Glaciers depositional landforms (after Christopherson, R.W., Geogsytems, 1996, p.435)

(iii) Aeolian Landforms (Wind Action)

Aeolian is a term pertaining to the wind; hence wind-borne, wind-blown or wind deposited materials are often referred to as aeolian landforms. Wind as an effective agent in eroding, the landscape, but it can transport loose, unconsolidated fragments of sand and dust. Winds vary considerably in strength from one moment in time to the next and are thus able to lift and transport rock debris for only short period.

Thus, wind is a significant erosion and deposition agent. It is responsible for the formation of great *'seas of sand'* in Arabia, Sahara, Australia, Namibia, Arizona, Patagonia, Kalahari, Thar, Gobi, etc. **(Fig. 2.55).** According to one estimate wind blown dust covers about one-tenth of the land surface. This fact is important because soils from these deposits constitute some of the richest soils of the Earth.

Deserts are among the most inhospitable places on the Earth. Some deserts are scorching hot, others are freezing cold, but they have one thing in common – they are all dry. Very few plant and animal species can survive in these harsh conditions. The world's coldest and driest continent, Antarctica, is a cold desert.

Wind action is quite pronounced in the arid and semi-arid areas of the world where the absence of vegetation cover and presence of extensive desolate rocks help in the erosion, transportation and depositional processes. Apart from the deserts, arid regions, wind action is also quite significant on sandy coasts, outwash plains of glacial areas.

Erosion by Wind

Wind performs erosion through the processes of: (i) attrition, (ii) deflation, and (iii) abrasion.

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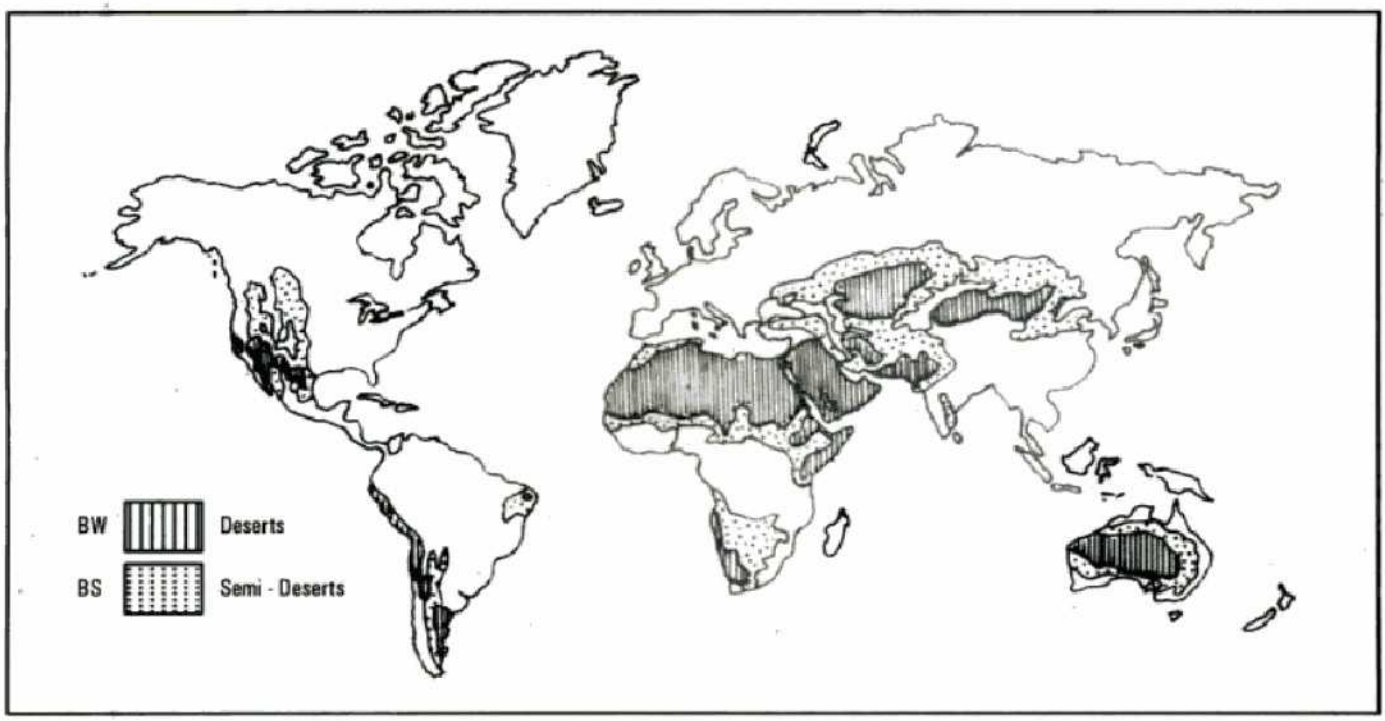

Fig. 2.55 – Deserts and semi-desert regions of the world

(i) Attrition

The mechanism by which the particles size of any material is reduced by friction during transport by an agent of erosion (running water, wind, sea-waves, etc.) is known as attrition.

(ii) Deflation

The process whereby the wind removes fine material from the surface of a beach or a desert. It is a process which contributes to the development of loess, dust storms and some stone pavements.

(iii) Abrasion or Corrasion

The process of wearing down or wearing away by friction as by windborne sand or material frozen into glacial ice.

Transportation by Wind

Wind transports dust, sand and pebbles, etc. in several ways. The fine, light materials are picked up, suspended in the air and carried away. Heavy of large sand-grains are dragged along the surface of the ground. In other words, wind transports sand by the process of saltation and surface creep. Most of the load is carried by wind in suspension. The quantity of material transported by the wind depends upon the size and amount of particles and the velocity of wind. The dust-storms carrying dust at long distances are known as *Haboobs* in Arabic language, especially in Sudan, Egypt. Saudi Arabia and Yemen.

Erosional Landforms by Wind Action

The main erosional features of wind action are : blowouts of deflation basins, bowls and caves, demoiselles, and desert pavements, dreikanter, inselberg, ventifacts, wind-bridges, yardangs, zeugen (mushroom-rock).

Demoiselles

A pillar of Earth or other unconsolidated material that is protected from erosion by a capping boulder **(Fig. 2.56)**.

Desert Pavements

The mountain wash containing pebbles, gravels and sand is exposed to wind. So, the fine material is soon removed, leaving a mosaic of pebbles which has been fittingly called desert pavement.

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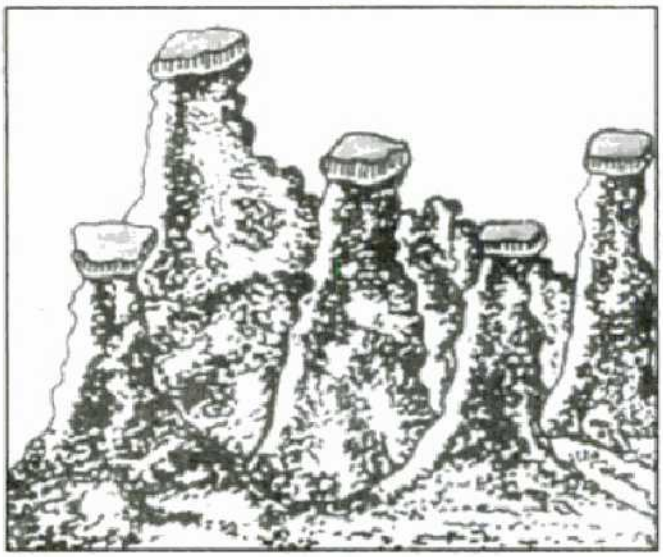

Fig. 2.56 – Demoiselles

Bowls and Caves

Depressions and caves are formed through the combined work of chemical weathering and wind. Usually, they are formed in massive sandstones whose cementing material is calcium carbonate.

Dreikanter

A pebble found on the surface in desert regions; it has three distinct facets on its upper surface as a result of wind abrasion.

Inselbergs

'Inselberg' is a German word (literally, island mountain) that has been widely adopted to describe a prominent steep-sided hill or solid rock, rising abruptly from a plain of low relief. Inselberg in arid regions are also called as *'hornhardts'* The Ulluru (Ayers Rock) in the Northern Territory of Australia is one of the highest inselbergs in the world **(Fig. 2.57)**.

Ventifacts

A stone that has been shaped by the wind, especially in arid areas. Abrasion is achieved by sand, dust and snow, and the stone becomes shaped and have surface textures that may be polished, pitted or fluted. They have some utility for estimating past and present wind directions.

Wind Bridge

The continuous abrasion of a rock by powerful wind results into the formation of holes in the rock which are gradually widened. Such holes are called as wind windows. The wholes are further widened and enlarged through the process of abrasion and deflation in such a way that an arch-like feature having intact roof is formed.

Yardang

Stream-lined wind erosion forms with their long axes parallel to the wind. They are often described as resembling an inverted ship's hull, although in many cases they are flat topped. Length to width ratios are commonly 3:1 or greater. Height varies from few metres to 200

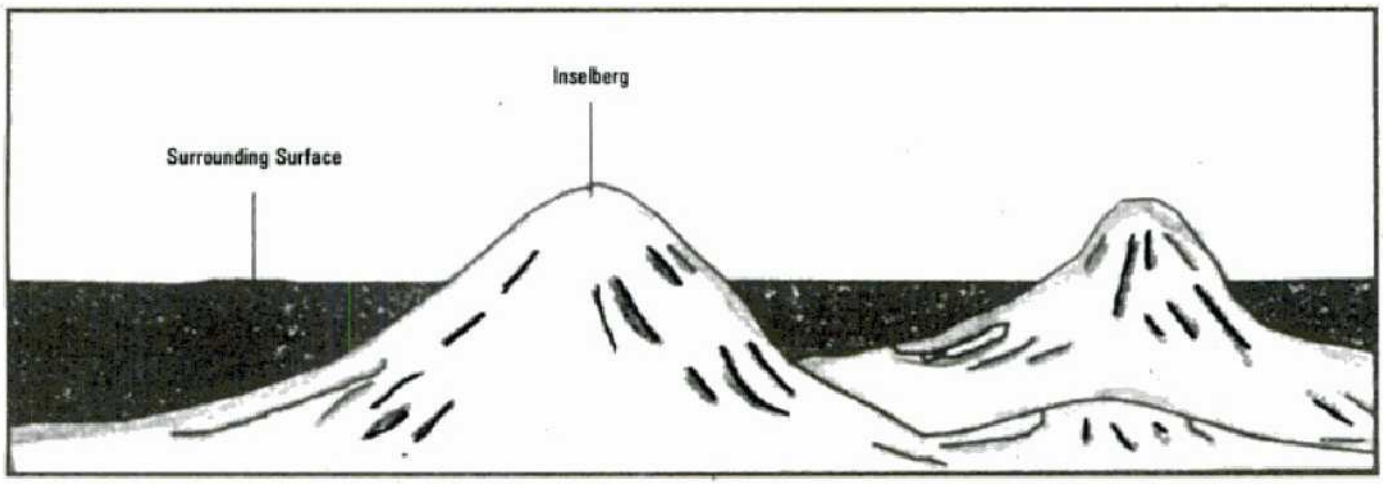

Fig. 2.57 – Inselberg

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Fig. 2.58 – Yardangs

Fig. 2.59 – Zeugens (Rock Mushroom)

metres. Yardangs parallel to one another and are separated by either U-shaped of flat-bottomed troughs **(Fig. 2.58)**.

Zeugens (Rock Mushrooms)

It is the tabular mass of rock perched on a pinnacle of a softer rock as a result of erosion, usually by the wind **(Fig. 2.59)**.

Depositional Landforms by Wind

Bahada (Bajada)

'Bahada' is a term derived from the Spanish language. It is used to describe the gentle, sloping surface leading down from a mountain front to inland basins in an arid region. It is composed of unconsolidated materials, such as sand, gravel, and angular scree, which together mantle the underlying rock-cut /pediment **(Fig. 2.60)**.

Barchan

A crescent-shaped sand dune in which the horns point down wind in the wind direction of dune migration. Barchans are a type of transverse dune that tends to form where either sand transport rates are high and/or sand supply is limited, Thus, they frequently occur on the margins of sand seas and migrate over non-sandy surfaces **(Fig. 2.61)**.

Dunes

A dune is a subaerial accumulation of sediment. Dunes are formed by the wind in desert and semi-desert environment. Dunes may vary in size from less than a metre to over 200 m high, they may be longitudinal (*Seif-dune*), transverse, parabolic and star-shaped **(Fig. 2.62)**.

Loess (Loss)

Originally referring to a loose, fine and sharp-grained soil occurring in the Rhine Valley, this term has been extended to refer to any unconsolidated, non-stratified soil composed primarily of silt-sized particles. It is very fertile agricultural soil. Loess deposits are found in Hawang-Ho basion, Mississippi valley, Patagonia, New Zealand, Tunisia, Negev, Central Europe, Central Asia, China and Pakistan **(Fig. 2.63)**.

Pediment

A term applied by G.K. Gilbert (1880) to alluvial fans flanking the mountains in Utah (USA). It is a low-angled plain found at the foot of mountain, especially in semi-arid regions.

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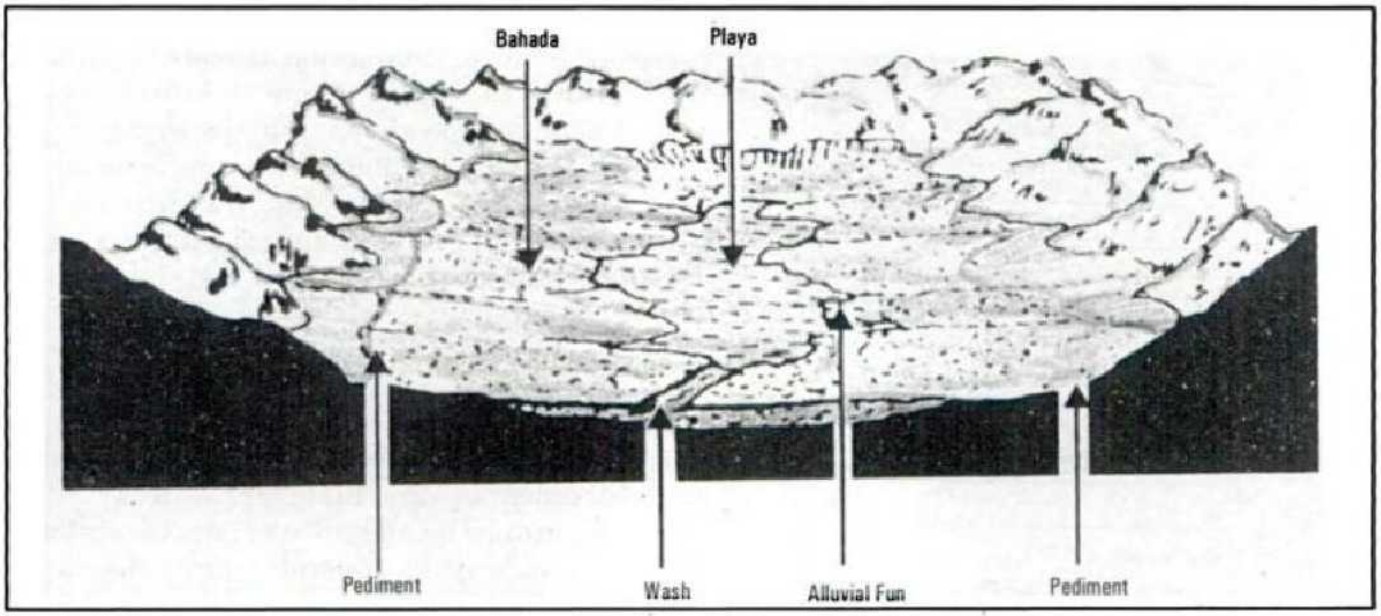

Fig. 2.60 – Bahada and Playa

Ripple

Ripples are small waves produced on a surface of sand or mud by the drag of wind or water moving over it. Ripples are more pronounced in the desert and develop when the wind blows at a gentle pace.

Sand Seas

The hot deserts in several continents are covered with wind-blown sand. These areas are referred to as *sand seas* or *ergs*. The largest sand seas are found in Saudi Arabia (Rab-al-Khali).

(iv) Erosional Processes by Ground Water

Water that occupies pores, cavities, cracks and other spaces in the rocks of the crust is known as ground water, sub-surface water or underground water. The ground water is distributed everywhere beneath the surface of the Earth. It occurs not only in humid areas, but also beneath desert regions. In many areas, the amount of water seeping into the ground equals or exceeds the surface runoff. Here, a brief description of the underground water, especially in the *karst* (limestone) topography has been given.

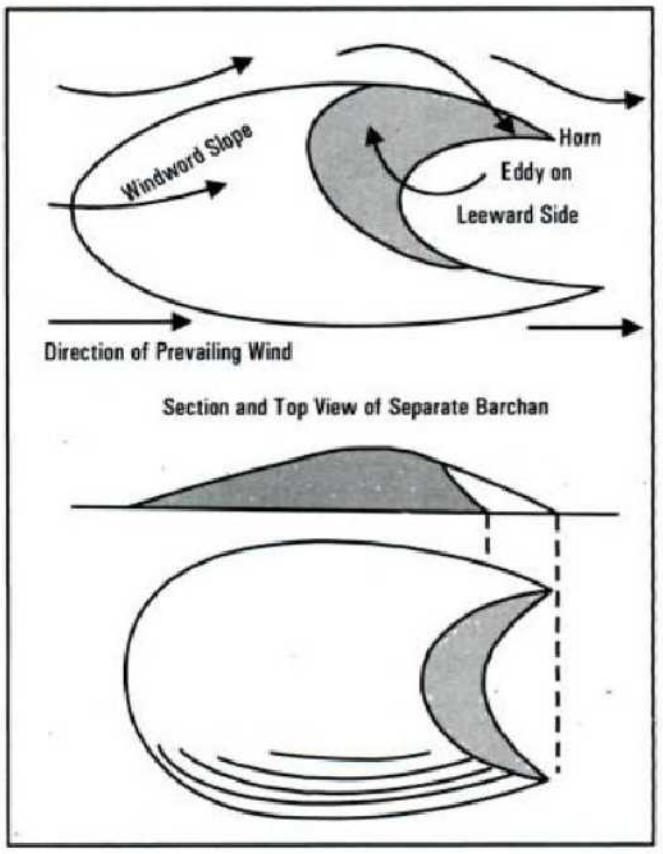

Fig. 2.61 – Barchans

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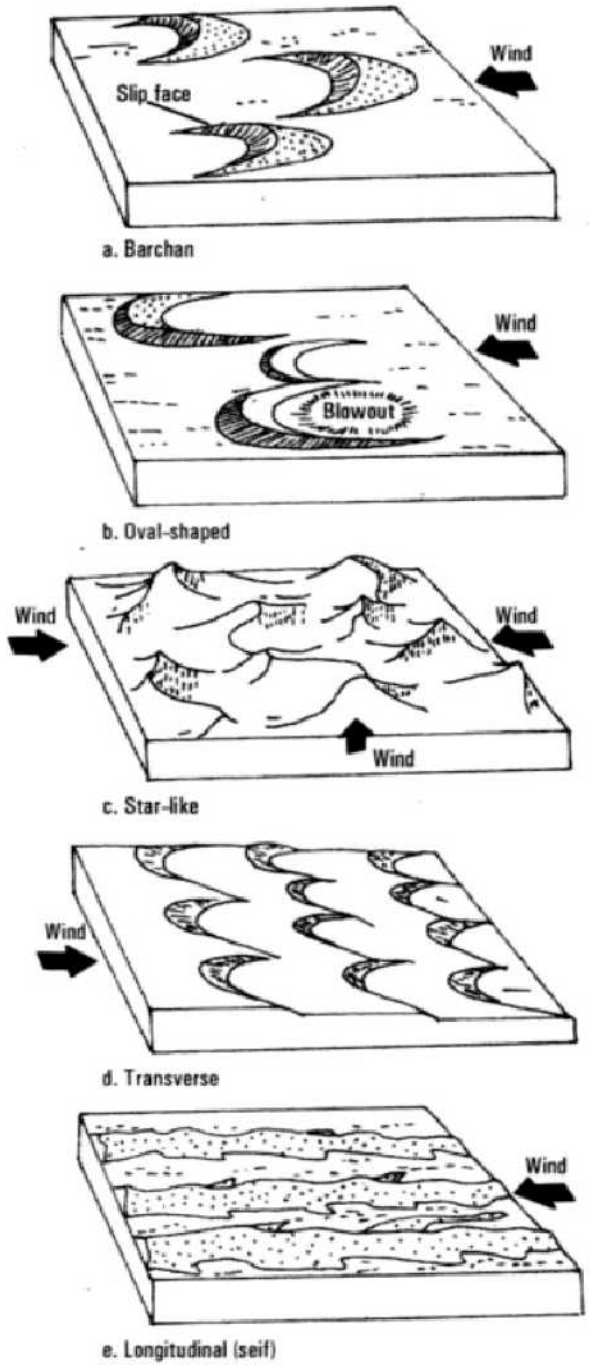

Fig. 2.62 – Types of sand-dunes

Karst

Karst is a distinctive topography formed in a region of chemically weathered limestone with poorly developed surface drainage and drainage features that appear pitted and bumpy; originally named after the *Krs Plateau* of Yugoslavia **(Fig. 2.64).**

Karst regions are typified by the dominant erosional process of solution, the lack of surface water and the development of stream sinks (dolines) cave systems and resurgences or springs. All the resultant landforms associated with karst scenery depend upon the phenomenon of stream sinking. Karst topography however, lacks a well-integrated drainage system.

Conditions for the Development of Karst Topography

The conditions that contribute to the maximum development of karst topography are:

1. There must be present at or near the surface a soluble rock, preferably limestone. The limestone must be massive, thickly bedded, hard, tenacious and well cemented.
2. The soluble rock should be dense, highly jointed, and preferably thinly bedded.
3. Existence of entrenched valley below uplands underlain by soluble and well-jointed rocks.
4. The climate should be humid-temperate. Karst topography does not develop in desert areas.
5. The region must receive moderate rainfall.

Aven

It is a French term for shaft-like hole in limestone terrain leading down into extensive cave system.

Carren (Lapies)

Karren is a German term initially used to describe minor and major solution furrows or funnels cut by ground water into karst topography. Now the term is used for highly corrugated and rough surface of lime stone lithology characterized by low ridges and pinnacles, narrow clefts, and numerous solution holes **(Fig. 2.65).**

Cave

A cave is a naturally formed subterranean open area, chamber or series of chambers commonly produced in limestone by solution activity **(Fig. 2.66).**

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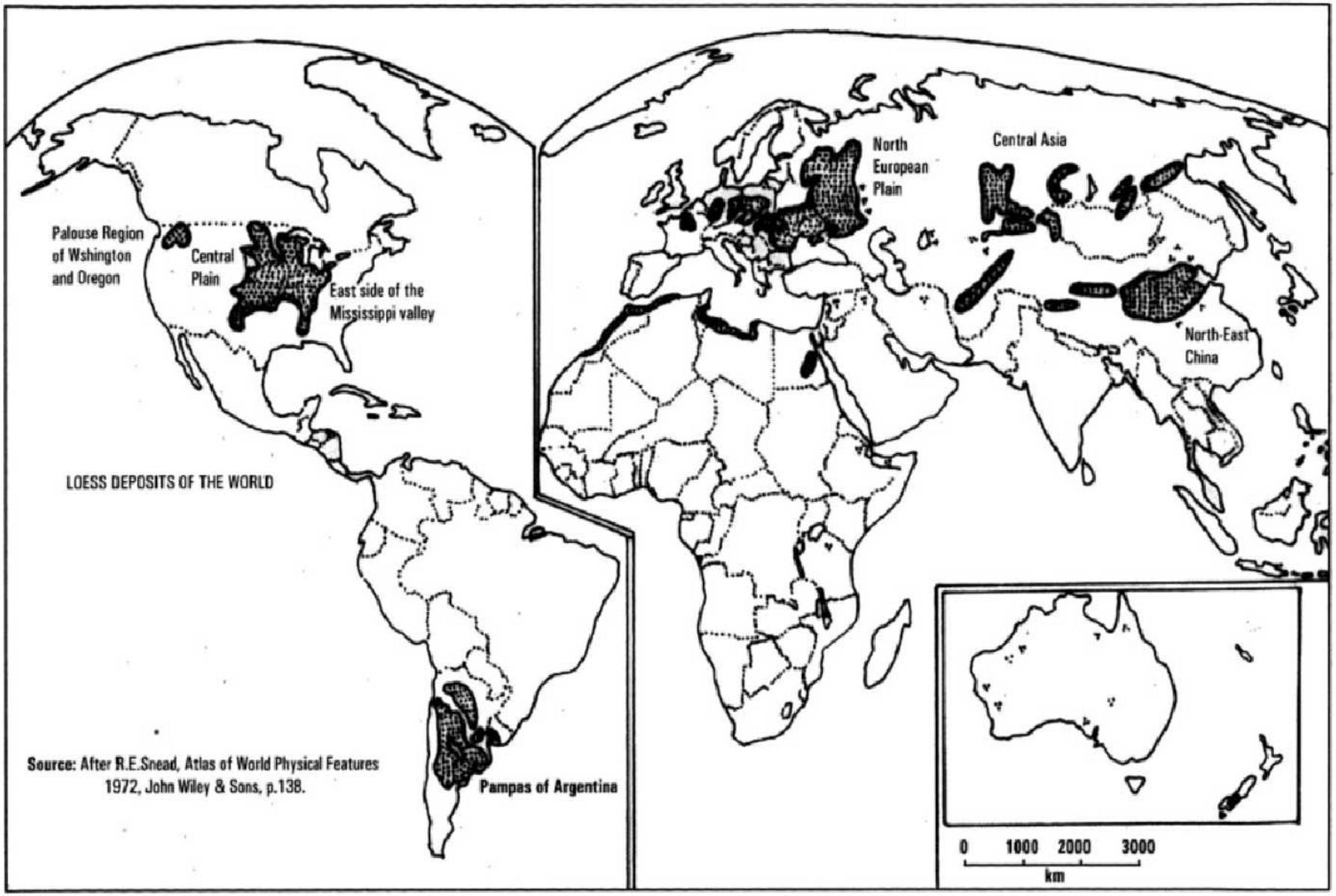
Palouse Region of Wshington and Oregon
Central Plain
East side of the Mississippi valley
North European Plain
Central Asia
North-East China
LOESS DEPOSITS OF THE WORLD
Source: After R.E.Snead, Atlas of World Physical Features 1972, John Wiley & Sons, p.138.
Pampas of Argentina
0 1000 2000 3000
km

Fig. 2.63 – Worldwide loess deposits

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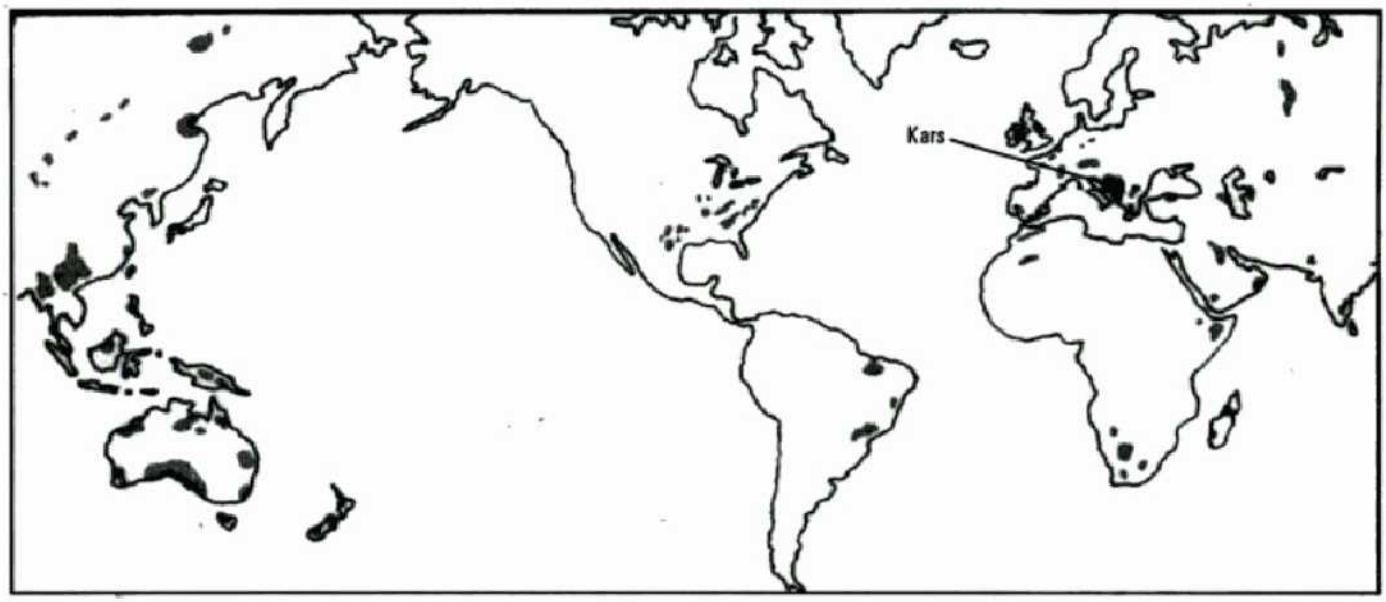

Fig. 2.64 – Major areas of Karst topography of the world

Erosional Landforms

Generally karst topography is characterized by: caves, karren, dolines, sink-holes, ponores, uvala, polje, Aven, natural bridge, springs, blind-valleys, etc **(Fig. 2.65 & 2.66)**.

Lapies

It is a French term for karren.

Natural Bridge

It is an erosional feature in karst topography. It is formed either due to the collapse of the roof of caves or due to the disappearance of surface streams as subterranean streams.

Polje

Polje is a large depression in a karst region with steep sides and flat valley floor **(Fig. 2.66)**.

Ponores

A vertical pipe-like passage that connects the caves and the shallow holes **(Fig. 2.66)**.

Sinkhole

A sinkhole is a depression formed by the collapse of a cavern roof **(Fig. 2.66)**.

Uvala

Uvala is a depression formed when two or more dolines coalese. The size of the hollow is not important in the recognition of uvala.

Depositional Landforms

The main depositional landforms in a limestone topography are given below:

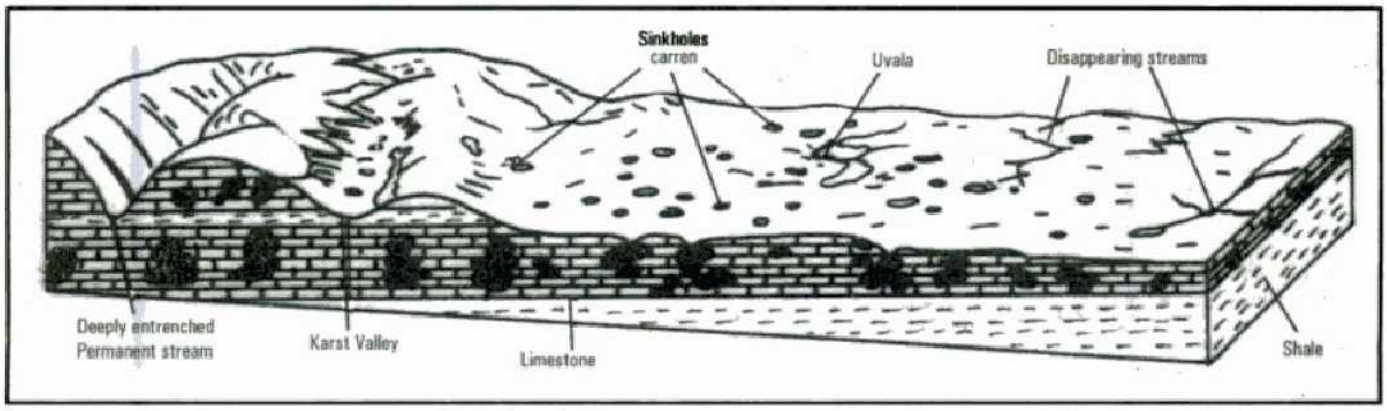

Fig. 2.65 – Salient features of karst topography

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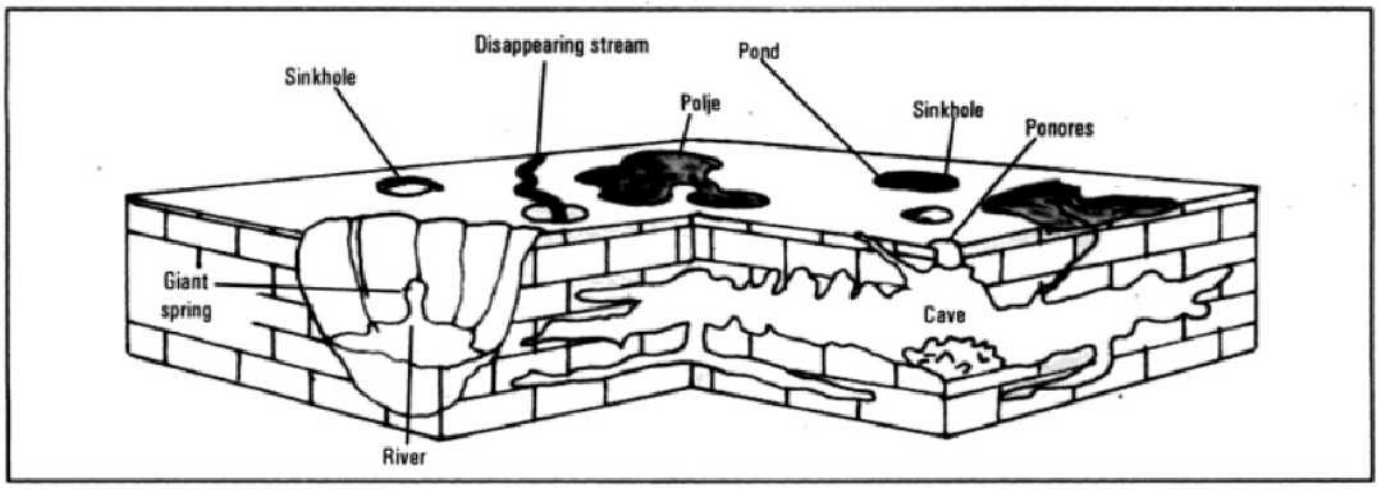

Fig. 2.66 – Karst topography

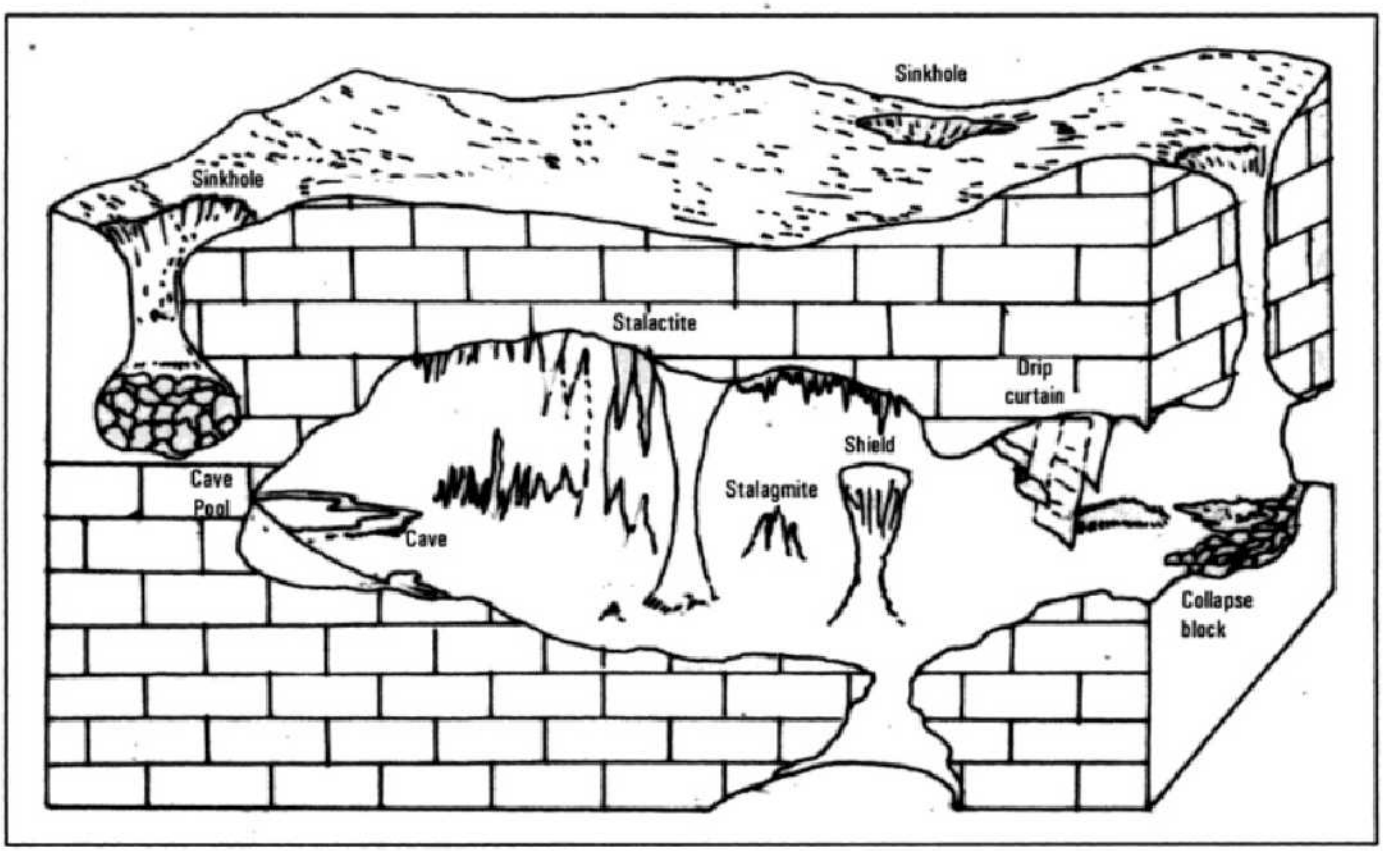

Fig. 2.67 – Karst deposits

Cave Pillars

These are formed when stalactite and stalagmite meet together.

Drip-Curtain

Numerous needle-shaped dripstones hanging from the cave ceiling are called as drip curtains or drapers **(Fig. 2.67).**

Stalactites

A column of pure limestone hanging from the roof of a cave. These are icicle-like forms that hang from the roof of a cave. In fact, these are tapering pendants of concretionary material descending from a cave ceiling, created by the precipitation of carbonate in calcite from percolating groundwater **(Fig. 2.67).**

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Stalagmite

These are columns of pure limestone formed on the floor of a cave when dissolved calcium carbonate in the underground water is deposited and water evaporates as it splashes onto the cave floor **(Fig. 2.67)**.

Terra-Rossa

Terra-Rossa is a red intra-zonal soil developed in the karst regions by the weathering of limestone. The red condition comes from the dissolution of clay to form iron-oxide.

(v) Coastal Processes (Marine Erosion) and Landforms

The processes of erosion and deposition and the resultant landforms along the coasts have been briefly described in the following:

Erosional Landforms

Arch (Sea-arch)

In coastal geomorphology an arch is made when two caves occurring on either side of a headland are cut until they meet. Roof falls cut-off the seaward end of the arch which is then left as a stack **(Fig. 2.68)**.

Beach

Thick wedge-shaped accumulation of sand, gravel or cobbles in the zone of breaking waves

Cliff

Marine cliff: It is rock cliff shaped and maintained by the undermining action of breaking waves. In general, it is a sheer, near vertical rock wall formed from flat-lying resistant layered rocks, usually sandstone, limestone, or lava, may refer to any near vertical rock wall **(Fig. 2.68)**.

Sea-cave

A sea-cave is a large natural hollow in the cliff along the coast with horizontal opening **(Fig. 2.68)**.

Stack (Sea-stack, Needles, Columns, Pillars, Skerries)

A stack is an isolated columnar mass of bed-rock left standing in front of a retreating marine cliff **(Fig. 2.68)**.

Wave-cut Platform

A very gently slopping platform extending seaward from the base of the cliff. Platforms widen as the cliffs retreat. They are subject to

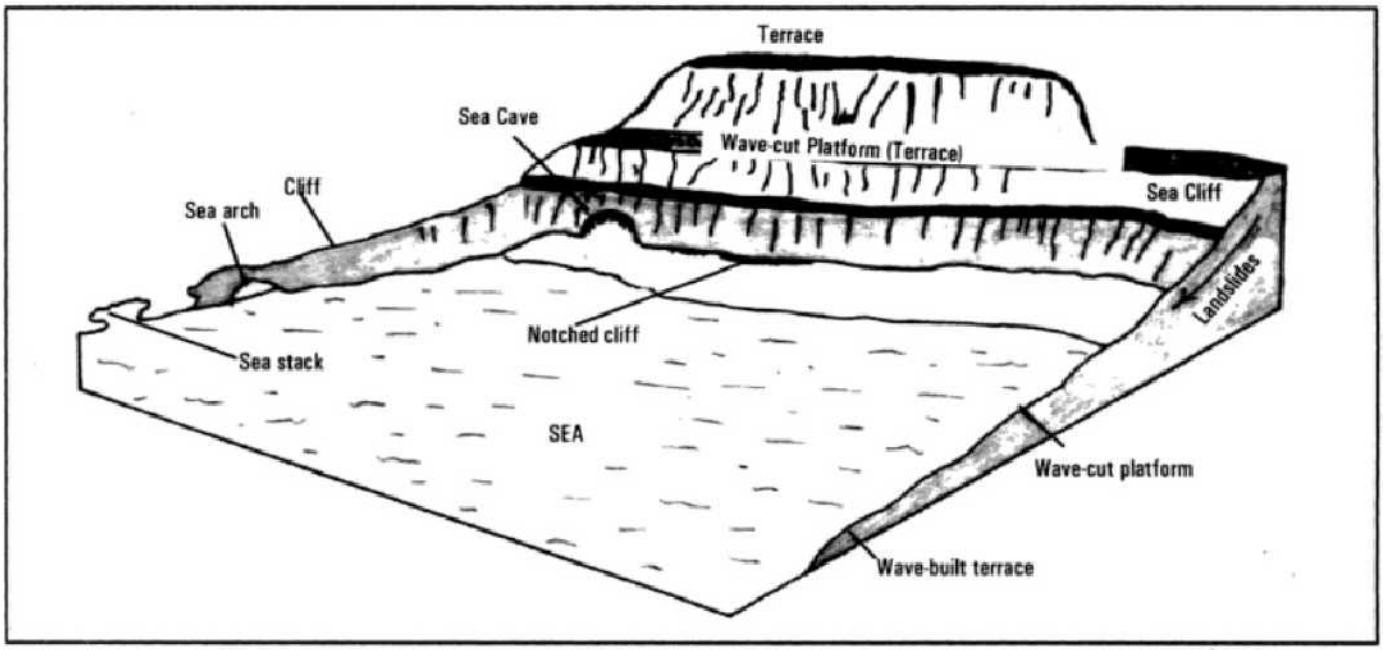

Fig. 2.68 – Coastal erosional land forms

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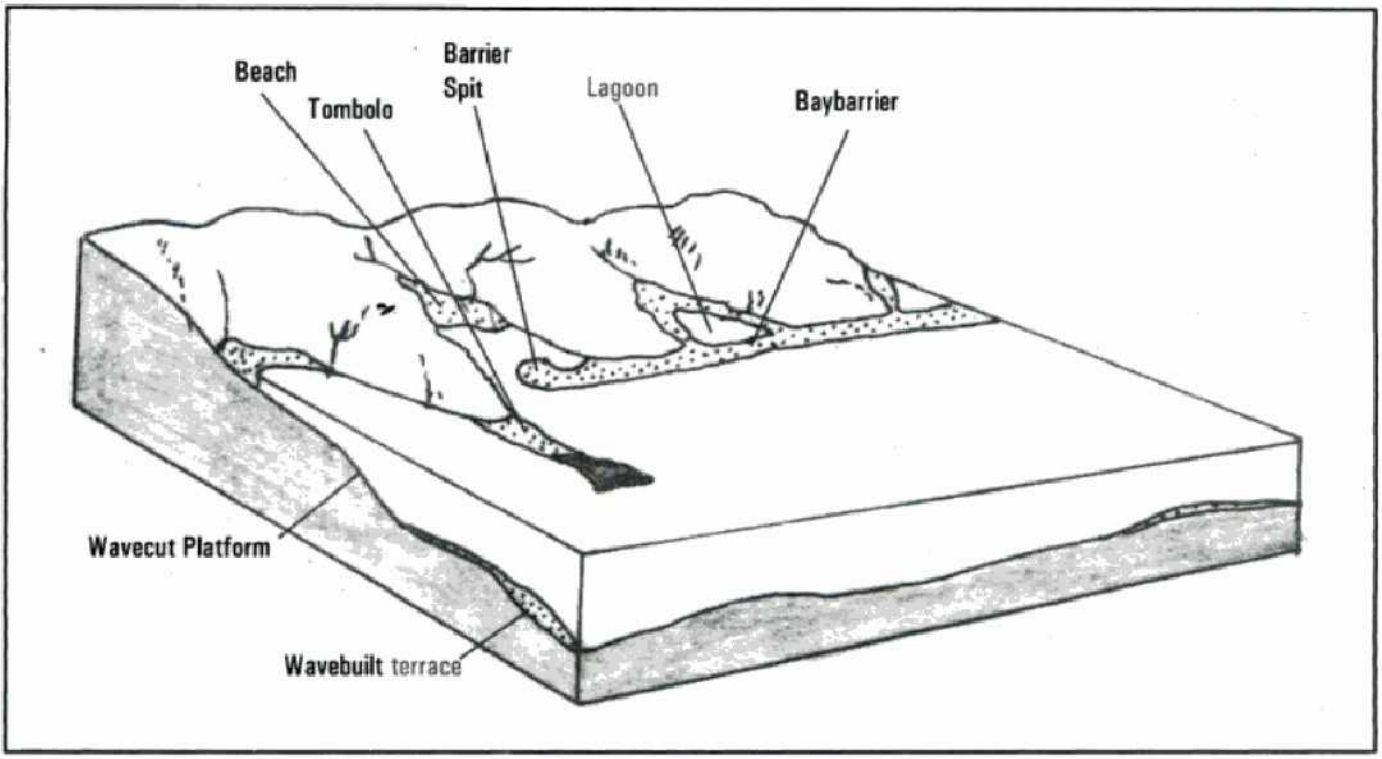

Fig. 2.69 – Coastal depositional landform

salt weathering, alternate wetting and drying and processes of erosion such as quarrying, hydraulic action and abrasion **(Fig. 2.68)**.

Depositional Landforms:

Bars

A low ridge of sand built above water level across the mouth of a bay or in shallow water paralleling the shoreline **(Fig. 2.69)**.

Spit (Sand-spit)

A narrow, fingerlike embankment of sand constructed by littoral drift into the open water of a bay **(Fig. 2.69)**.

Tombolo

A bar or spit connecting an island to the mainland or to another island **(Fig. 2.69)**.

Coasts Types

A coast is a zone in which coastal processes operate or have strong influence. Some of the important types of coasts have been defined in the following:

Dalmatian (Pacific/Concordant) Coast

This is a drowned seashore with the main relied trends running more or less parallel with the coastline, named after the Adriatic Coast **(Fig. 2.70)**.

Fiord (Fjord) Coast

Deeply embayed, rugged coast formed by partial submergence of glacial trough.

Ria Coast

The seaward end of a river valley which has been flooded as a result of rise in sea level. The name is from the Spanish language. The Cork harbor in Ireland is a ria coast **(Fig. 2.71)**.

Slopes or Hill-slopes

Slopes are curved, inclined surfaces essential slope forms that may vary with conditions of rock structure and climate. Slopes generally feature an upper *waxing slope* near the top ('waxing' here means increasing). This convex surface below. The presence of a free face indicates an outcrop of resistant rock that

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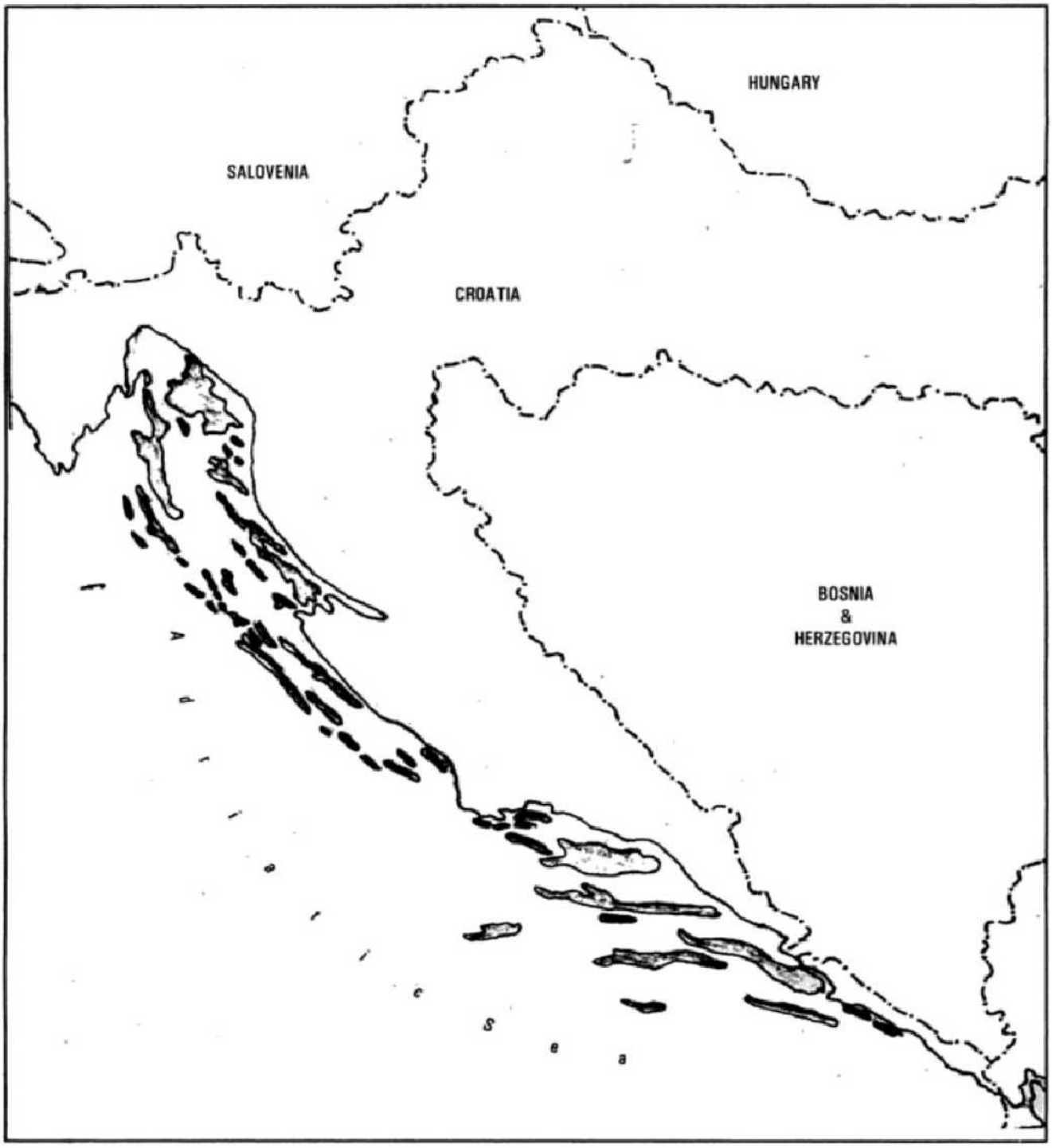

Fig. 2.70 – Dalmatian coast

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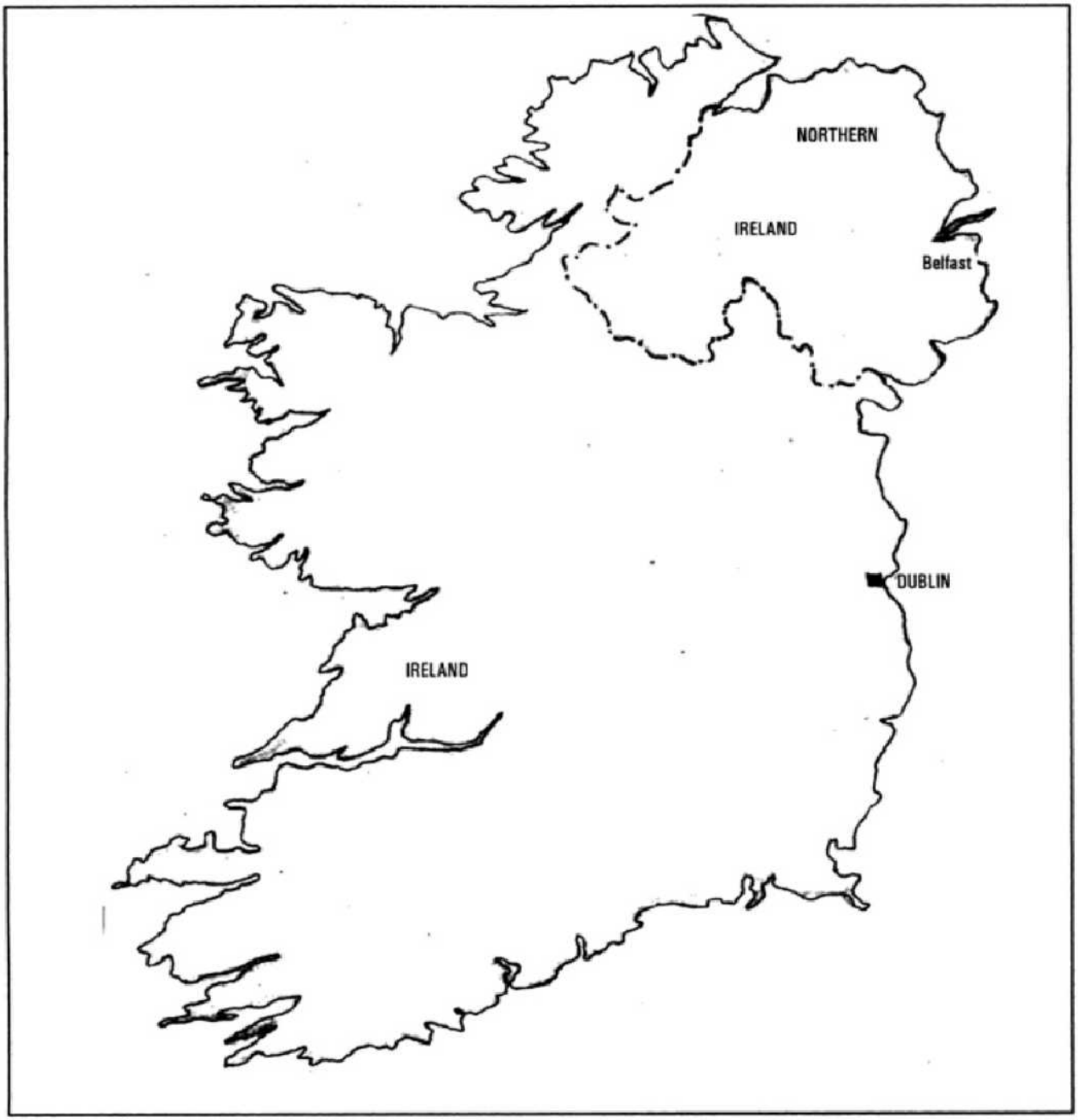

Fig. 2.71 – Ria-coast

forms a steep scarp of cliff. Down-slope from the free face is a debris slope that receives rock fragments and materials from above.

In humid climates constantly moving water carries away material as it arrives, whereas in arid climates, graded debris slopes persist and accumulate a debris slope grades into a waning slope, a concave surface along the base of the slope that forms a pediment, or broad, gently sloping erosion surface.

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Chapter Three

Climatology

Chapter Concepts

- Atmosphere
- Atmosphere Pressure
- Atmospheric Circulation
- Horizontal Distribution of Air Pressure
- Meridional Circulation
- Moisture in the Atmosphere

Atmosphere

The atmosphere is a thin envelop of gases surrounding the Earth that forms a protective boundary between the outer space and the biosphere generally considered to be below 480 km (300 mi). Earth's atmosphere is formed by gases from the crust and interior and the exhalations of all life over the time. Atmosphere is a mixture of gases that is odorless, colourless, tasteless, and formless, blended so thoroughly that it behaves like a single gas. Earth's atmosphere is unique because, it supports life.

The stabilisation of atmosphere in its present form took place in the *Cambrian Period* (about 600 million years ago). The gases of the present atmosphere are not direct residue of the earliest form of the planet rather they are evolutionary products of the volcanic eruptions, hot springs, chemical breakdown of solid matter and distribution from the biosphere including photosynthesis and human activity.

Composition of Atmosphere

The main gases and their proportions have been shown in **Fig. 3.1**. A unit mass of dry air is made up of 78.084 per cent nitrogen (N_2), 20.946 per cent oxygen (O_2), 0.934 per cent argon (A), 0.036 per cent carbon dioxide (CO_2), and smaller proportions of rare gases such as neon, helium, methane and hydrogen.

1. On the basis of composition of gases, the atmosphere may be divided into (i) Heterosphere, and (ii) Homosphere **(Fig. 3.2)**.

Homosphere

It extends from the Earth's surface up to an altitude of 80 km (50 miles). Even though the atmosphere rapidly decrease in density with increasing altitude, the blend of gases is nearly uniform throughout the homosphere. The only exceptions are the concentration of ozone (O_3) in the stratosphere (ozone layer) from 19 to 50 km, and the variation in water vapour and pollutants in the lowest portion of the atmosphere near the Earth's surface. The stable

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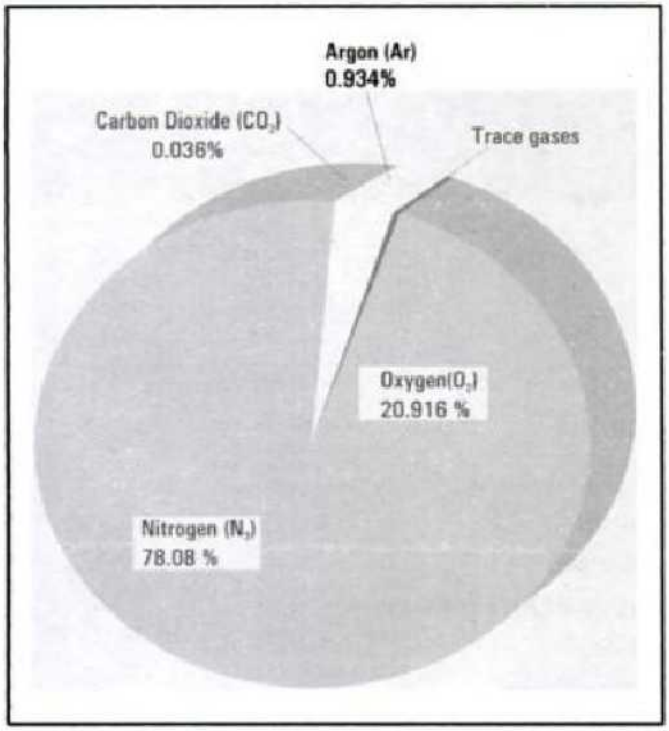

Fig. 3.1 – Stable components of modern atmosphere (Percentage concentration by volume)

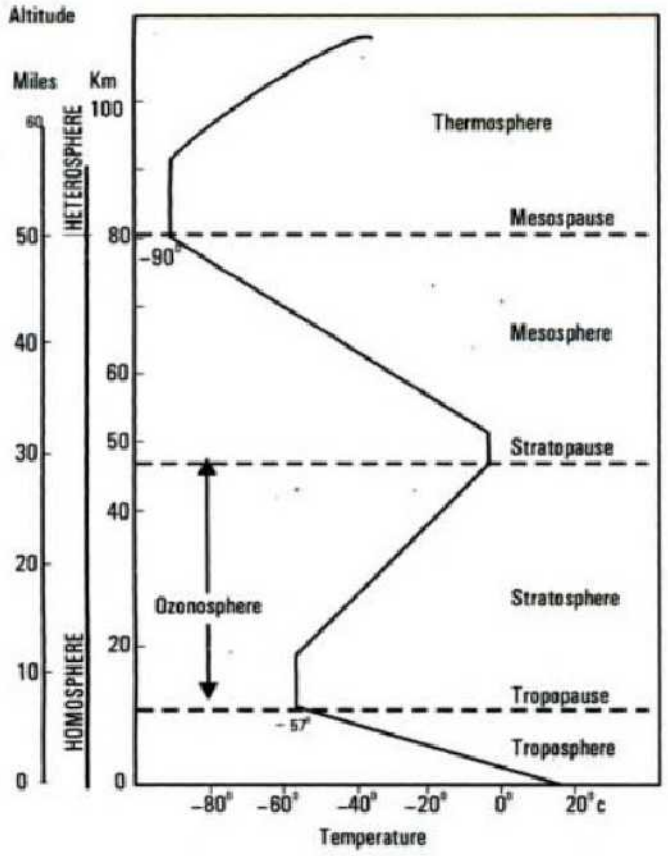

Fig. 3.2 – Vertical structure of atmosphere

mixture of gases throughout the homosphere has evolved slowly. The present proportion, which includes oxygen, was attained approximately 600 million years ago (*Cambrian Period*).

The homosphere may be divided into:
(1) Troposphere, (2) Stratosphere, and
(3) Mesosphere.

Troposphere

Troposphere extends up to the tropopause, defined by a temperature of -57°C, occurring at an altitude of 19 km at the equator, 13 km in the middle latitudes, and about 8 km near the poles. It contains approximately 90 per cent of the total mass of the atmosphere and the bulk of all water vapour, clouds, weather, and air pollution. The height of the tropopause varies with season, latitude, surface temperatures and pressures. The normal decrease in temperature in the troposphere has been shown in **Fig. 3.3.** The temperature in the troposphere decreases at the rate of 6.4°C per 1000 meters. This decrease in temperature is known as the *normal lapse rate.*

Stratosphere

Above the troposphere lies the stratosphere. The troposphere ranges from about 19 to 50 km above the Earth's surface on equator. The temperature in the troposphere varies from -57°C at the tropopause to 0°C at the stratopause (50 km). This sphere is characterised by the presence of ozonosphere, or ozone layer. Ozone is highly reactive oxygen molecule made up of three oxygen atoms (O_3). That make up most of the oxygen gas. Ozone absorbs wavelengths of ultraviolet light. Through this process, the most harmful ultraviolet radiation is effectively 'filtered' from the incoming solar radiation, safeguarding the Earth's surface.

Mesosphere

The Mesosphere is the area from 50 to 80 km. Its upper boundary, the mesopause, is the coldest portion of the atmosphere, averaging -90°C, although that temperature may vary by ± 25° to 30° C **(Fig. 3.4).**

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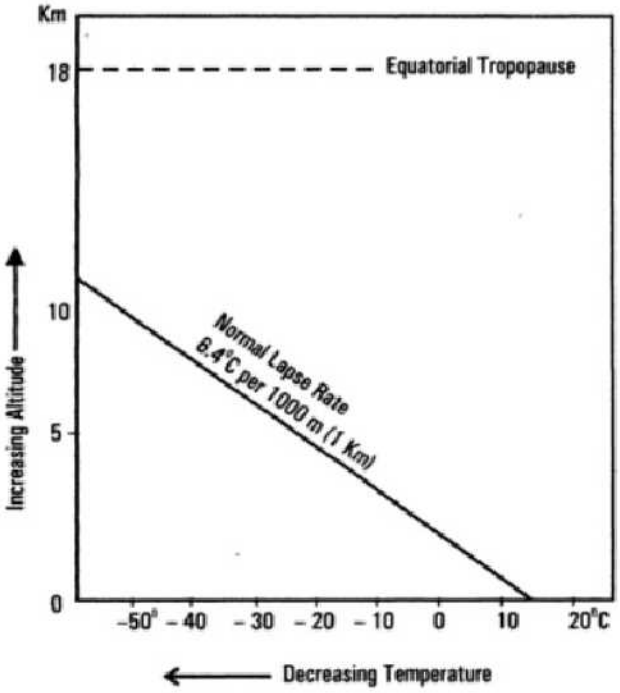

Fig. 3.3 – Normal lapse rate

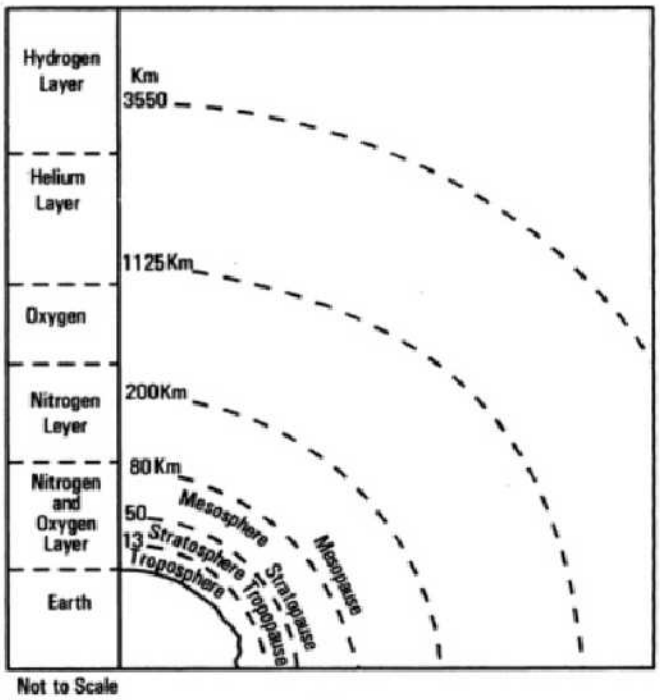

Fig. 3.4 – Chemical zones in the atmosphere

Heterosphere

The gases in this part are not evenly mixed. The heterosphere begins at around 80 km (50 mi) altitude and extend outward some 10,000 km. The solar constant is, however, measured at the altitude of 480 km. Above that point, the atmosphere is rarified (nearly a vacuum) and is called exosphere, which means '*outer space*'. It contains individual atoms of the light gases hydrogen and helium, weakly bound by gravity. The heterosphere has thermal region (called the thermosphere) and within it functional layers (called the ionosphere).

Thermosphere (the 'Heatosphere')

This is a region extending from 80 km to 480 km in altitude. It contains the functional ionosphere layer. High temperatures are generated into the thermosphere because the gas molecules in this sphere absorb shortwave solar radiation. The temperatures rise sharply in the thermosphere, up to 1200°C (2200°F) and higher. Despite such high temperatures, the thermosphere is not '*hot*' in the way you might expect. Temperature and heat are two different things. The intense solar radiation in this portion of the atmosphere excites individual molecules and atoms (principally nitrogen and oxygen) to high levels of vibration. The density of molecules is so low that little actual heat is produced (heat is the quantity of thermal energy). Heating in the lower atmosphere near the Earth's surface is different because the greater number of molecules in the denser atmosphere transmit kinetic energy as sensible heat, meaning that we can sense it **(Fig. 3.4)**.

Ionosphere

This is a zone of the upper atmosphere (Heterosphere) characterised by gases that have been ionized by solar radiation. The ionosphere is composed of atoms that acquired electrical charges when they absorbed cosmic rays, gamma rays, x-rays, and shorter wavelengths of ultraviolet radiations. These charged atoms are called ions, giving the ionosphere constantly, producing a constant flux (flow) of electrons and charged atoms.

The incoming solar radiation begins to interact with the atmosphere at altitudes beyond 480 km (300 miles). This outer region is also where gaseous particles escape the Earth's

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gravity. Particles are far apart that some of them have a high enough velocity in a direction away from the Earth to escape to space. The atmosphere is very thin at this altitude, but it is here that incoming space vehicles and meteorites begin to heat due to friction.

Above this, to perhaps 1125 kilometres (675 miles) atomic oxygen is prevalent. Beyond this layer of atomic oxygen, helium is most common out to 3540 km. Still farther out, hydrogen atoms predominate. The boundaries among the ozone is not clearly defined **(Fig. 3.4)**.

Solar Constant

The solar constant is the average value of insolation received at the *thermopause* (480 km or 300 miles) above the Earth's surface, when the Earth is at its average distance from the Sun. Solar constant is measured at a height of 480 km above the sea-level. The average value of solar constant is 1.968 calories per cm^2 per minute.

Heating of the atmosphere: The energy emitted by the Sun passes through space until it strikes some object. The quantity of radiation is about 1.968 calories per square centimeter per minute (*approximately 2 calories per cm^2 per minute*) which is known as solar constant. A calorie is the amount of energy required to raise the temperature of one gram of water (at 15°C) one degree Celsius. Thus, the solar constant is the basic amount of energy available at the outer limits of the Earth's atmosphere (480 km or 300 miles above the Earth's surface). Several processes deplete the solar radiation as it passes into the atmosphere. The processes include reflection, scattering, absorption, long wave-radiation, and transmission.

Reflection

The Earth and its atmosphere reflect part of the solar radiation back to space. There is considerable variation in reflection of natural surfaces. Reflectivity or *albedo* is expressed as a percentage of incident reaching the Earth's surface. Clouds are by far the most important reflectors in the earth environment. Cloud's reflectivity ranges from 40 to 90 per cent depending on the type and thickness. The most obvious effect of scattering in the atmosphere is sky colour. The only reason our sky appears blue is the of scattering of radiation in the shorter wave-lengths of visible light. Scattering also explains the orange and red colours seen at dawn and sunset. At these times, the radiation passes through the atmosphere at a very low angle. Thus, it passes a long distance through air close to the ground. The lower atmosphere contains not only the dry gases, but water vapour, solid particles, organic material, and salt. These larger particles scatter the long- wavelength radiation. In fact, the atmosphere absorbs most of the radiation in the shorter wave-lengths (violet to green). Only the longest wavelengths–orange and red – pass through.

Absorption

Sound or light energy gets converted into heat. Most often it changes to sensible heat, which raises the temperature of the absorbing object. For example, sunlight striking the side of a house is absorbed and heats the wall.

Transmission

Reflection, scattering, and absorption deplete the solar beam as it passes through the atmosphere.

Scattering

Scattering is a process by which small particles and molecules of gases diffuse part of radiation in different directions. The process changes the direction of radiation in a relatively random fashion.

Dawn and Twilight Concepts

The diffused light that occurs before sunrise and after sunset represents useful work time for humans. Light is scattered by the molecules of atmospheric gases and reflected by dust and moisture so that the atmosphere is illuminated. Such effects may be enhanced by the presence of pollution and other suspended particles, such as those from volcanic eruptions or forest

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fires. The duration of dawn and twilight is a function of latitude because the angle of the Sun's path above the horizon determines the thickness of atmosphere through which the Sun's rays must pass. Lower Sun angles produce longer dawn and twilight periods.

At the equator, where the Sun's rays are nearly perpendicular to the horizon throughout the year, dawn and twilight are limited to 30-45 minutes each. These times increase to 1-2 hours at 40° latitude, and at 60° latitude they range upward about 2.5 hours, with little true night in summer. The poles experience about *7 weeks* of dawn and *7 weeks* of twilight, leaving only 2.5 months of near darkness during the six months when the Sun is completely below the horizon.

Determinants of Temperature

The average temperature of the earth is about 15°C. Its distribution is, however, not even. The spatial distribution of temperature is determined by the following factors:

1. **Latitude :** The insolation and temperature of a place largely depend on latitude. The intensity of insolation decreases from the equator towards the pole. In addition, day-length and sun angle change throughout the year which affect the rate of insolation. Consequently, the lower latitudes record high temperature as compared to the higher latitudes.

2. Altitude : Within the troposphere, temperatures decrease with increasing altitude above the Earth's surface (the normal lapse rate is 6.4°C per 1000 m). Thus, world-wide mountainous areas experience lower temperatures than do regions near sea level, even at similar latitudes. For example, Libreville (Gabon) 15 m above the sea level, and Quito (Ecuador) about 2500 m above the sea level both are located almost on the equator. The mean annual temperature of Libreville is 28°C while that of Quito only 13°C. The great variation in temperature of the two places is simply because variation in altitude.

3. Cloud Cover: There is a direct effect of cloud cover on the amount of insolation. The cloudiness affects the local, daily, seasonal and annual temperatures and the ranges of temperatures. According to the meteorologists, over 50 per cent of the sky is overcast every day. Cloudy days are generally cooler and cloudy nights are warmer. The maximum clouds are recorded in the equatorial region. Consequently, the highest temperatures are not found along the equator. Conversely, the hot deserts have the minimum cloud cover as a result of which the highest temperatures are recorded along the Tropic of Cancer (places, like Al-Azizia (Libya), Death Valley (California), and Ganganagar and Jodhpur (India).

4. Distance from the Sea/Ocean: The location of a place in relation to sea and or oceans also affects the distribution of temperature. In fact, there is differential heating of land and sea at the same latitude. The sea water can pass its heat downward, or evaporation and ocean currents can reduce the surface temperature, but the land is opaque, and the Sun's rays on land can penetrate only up to a depth of only one meter, while they penetrate much deeper in water (seas/oceans). The two places situated at the same latitude – one along the sea coast and the other in the interior away from the coast – will record different temperatures. For example, Mumbai and Adilabad (Andhra Pradesh) are situated almost at the same latitude, but because of differential heating of sea-coast and interior land, there is a marked difference in their mean annual and diurnal range of temperature. The annual range of temperature at Mumbai is only about 6°C, while that of Adilabad is about 20°C. A typical example of extreme temperatures in summer and winters may be provided by the city of Tashkent. At Tashkent the mean maximum temperature of July is 40°C, while the mean minimum temperature of January reads -40°C. These extremes in temperature are the results high degree of continentality of Tashkent. In fact, Tashkent is quite far away from the ocean bodies and it is surrounded by the lofty mountains which create a strong barrier in the path of oceanic winds.

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5. Winds: The role of prevailing winds is also quite significant in the distribution of temperature. The winds help in the redistribution of temperature and in carrying moderating effects of the oceans to the adjacent coastal areas. For example, the wind blowing from low latitudes to high latitudes raise the temperature of the region, while winds blowing from high latitudes to low latitudes lower the temperature. The winds coming from the Siberia, significantly reduce the temperatures in the northern plains of China even along the coastal areas. Some of the local winds like *Gibli* (Libya), *Chinook* (USA-Canada), *Mistral* (France), and *Berg* (Germany) change the temperature dramatically. Similarly, *'Loo'* a local wind, raises the temperature in the Satluj-Ganga Plains of north India significantly.

6. Topography and Slope: The distribution of temperature is also affected by the physiographic features. The ground slope facing the Sun receives more insolation (temperature) than the leeward slopes. For example, the southern slopes of Himalayas record more temperature than that of the northern slopes. A north facing slope may have snow on it, whereas a south-facing slope is bare at the same altitude. The north slope gets less intense radiation and as the sun gets lower in the sky, will be in shadow long before the south facing slope. It is just the reverse in the case of Southern Hemisphere. The coastal windward slope of the mountains and hills have relatively low temperatures because of oceanic influence and ascending air than the leeward slope. This is why there is much difference in the temperature of Mumbai and Pune. Slope aspect influences many natural phenomena. For example, the height of permanent snow and ice on mountain varies from one slope to another as does the tree line. Similarly, the depths of snow and frost differ on north and south-facing slopes. These phenomena also affect the temperature.

Topography also plays an important role in climates of some lowlands. On a continental scale, mountain ranges that run north and south have very different effect from those run east west. The presence of the Himalayas obstructs the Siberian cold air to enter into the sub-continent of India. The heavy rainfall along the southern slopes of Himalayas is the result of obstruction it creates in the path of the Indian summer monsoon winds.

7. Ocean Currents: The ocean currents also affect the distribution of temperature on the land and oceans. The warm ocean currents flowing from the lower latitudes to the higher latitudes carry the warm water towards the polar areas, while the cold water currents bring the cold water towards the equatorial regions. For example, the Gulf Stream raises the average temperature of Norway coast by about 5°C, while the Labrador current reduces the temperature of the Canadian coast by about 8°C. Because of the warm water of the Gulf-Stream, the ports of the northern Europe (60°N) remain open throughout the year, while the ports of Canada even at 50°N remain frozen during the winter season.

Horizontal Distribution of Temperature

The horizontal distribution of temperature is also known as regional distribution of temperature. The horizontal distribution of temperature on the earth surface is not uniform. The horizontal/regional distribution of temperature is controlled by several physical factors, e.g. (i) latitude, (ii) altitude, (iii) cloud cover, (iv) distance from the sea, (v) winds, (vi) slope of land, and (vii) ocean currents.

In general, the temperature decreases from equator towards poles. The rate of decrease in temperature from equator towards pole is known as *temperature gradient*. Since the tropical zone receives the highest insolation, the average temperature in this zone are high throughout the year. The presence of clouds in the equatorial belt, however, obstructs the rate of insolation. Consequently, the highest temperatures are not recorded along the equator, instead, the regions of Tropic of Cancer and the Tropic of Capricorn. In the western parts along the Tropic of Cancer and Tropic of

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Capricorn, the skies remain clear over the greater parts of the year. Consequently, the highest temperatures in the world are recorded along the tropics, especially in the hot deserts.

Normally, isotherms run east-west and are almost parallel to the latitudes. This trend shows strong control of latitudes on the horizontal distribution of temperature. Isotherms are, however, more irregular in the Northern Hemisphere because of large extent of land-mass. Moreover, isotherms are more closely spaced in the Northern Hemisphere which shows a rapid change in temperature. The isotherms of January and July are the representatives for the horizontal distribution of temperature.

Thus, the horizontal distribution of temperature over the Earth's surface is a function of both location (latitude, altitude and slope), and dynamic movement (energy transfer by atmosphere and ocean currents).

January Temperature

The distributional pattern of temperature in the month of January has been shown in **Fig. 3.5.** In January the Sun's rays are vertical in the Southern Hemisphere. Consequently, higher temperatures are recorded in the Southern Hemisphere. The thermal equator (a line joining all points of highest mean temperature) tends southward into the interior of South America, Africa and Australia indicating higher temperatures over landmasses. The isotherms generally run parallel to the equator. The coldest area in the month of January lies in the Siberia. Verkhoyansk and Oyamakon (Russia), each has recorded a minimum temperature of -68°C, and a daily average of -50.5°C for January **(Fig. 3.5).**

July Temperature

The mean July temperatures have been shown in **Fig. 3.6**. In July, the longer days of summer and vertical rays of the Sun are in the Northern Hemisphere. The thermal equator shifts northward with the high summer Sun and reaches the Libya, Egypt, Saudi Arabia, Persian Gulf, Iran, Pakistan and Central India. The highest temperature was recorded at *Al-Azizia 58°C on 13th September, 1922* **(Fig.3.6).** On water, the Persian Gulf is the site of the highest recorded sea-surface temperature of 36°C, difficult to imagine for a sea or ocean body **(Fig.3.6).**

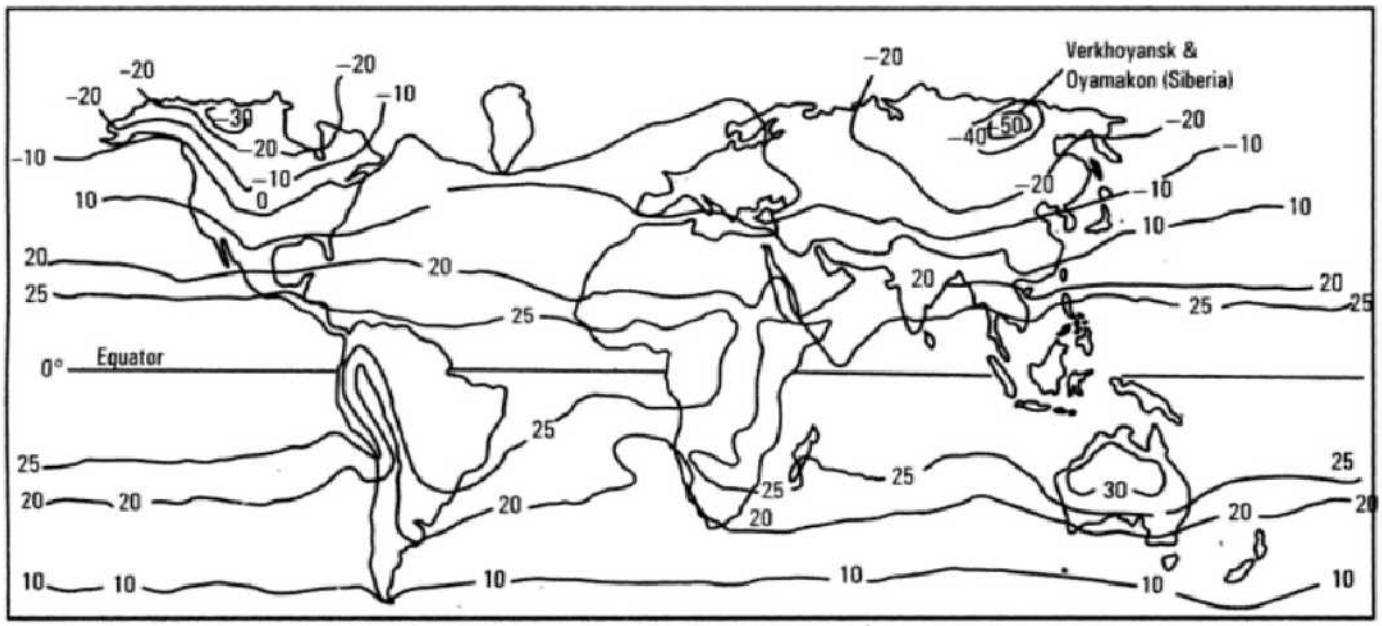

Fig. 3.5 – Mean January temperature

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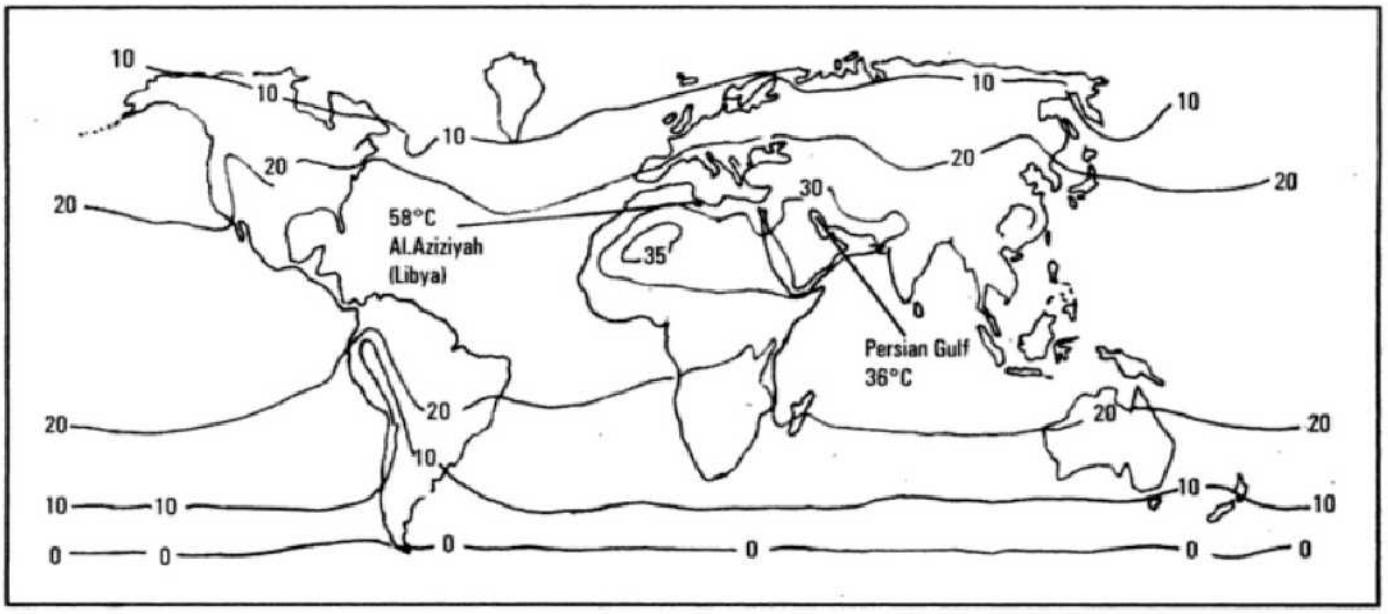

Fig. 3.6 – Mean July temperature (°C)

Annual Range of Temperature

The difference of the mean monthly temperature of January and July is known as the annual range of temperature. The highest annual range of temperature is generally recorded in the sub-polar region in Siberia where the average annual ranges of temperature is about 64°C **(Fig.3.7).** The annual range of temperature to the west of Bay of Hudson is also around 60°C. The Southern Hemsiphere, on the other hand, produces relatively little annual range in mean temperature. In general, the Northern Hemisphere, with greater land area overall, registers a slightly higher average surface temperature (15°C) than does the Southern Hemisphere (12.7°C).

Diurnal Range of Temperature

The difference of the highest and the lowest temperature in a day at a given point is known as the diurnal or daily range of temperature. The highest diurnal range of temperature is recorded in the hot deserts of the world.The magnitude of the daily change in temperature varies a great deal. Near the equator, the daily range exceeds the annual range. Near the two poles, the daily range is reduced to almost zero since there is generally only one daylight and one nighttime period each year.

The daily range of temperature over the oceans is also small. There are several reasons for the low range. First is the high specific heat of water. The oceans heat slowly and cool slowly. Second, there is mixing of the surface water with the water below that modifies heating and cooling. Third, solar radiation penetrates deeper into the ocean than into the land. Fourthly, the ocean currents mitigate the temperature.

The daily range of temperature in the Sahara Desert (*Al-Aziziyah*) and the Desert of Arizona, is more than 22°C. The greatest known recorded daily range in temperature occurred in Libya (North Africa), where the temperature dropped from a high of 56°C in the afternoon to 0° the following morning (September, 1922). The difference is an amazing 56°C.

Inversion of Temperature

Generally the temperature decreases in the troposphere with height at the rate of 6.4°C per 1000 m. If there is an increase of air temperature with increase in height, it is known as inversion of temperature. This is also

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called as the *negative lapse rate*. The inversion of temperature may occur, near the Earth's surface, or at greater height in the troposphere. Different types of inversion of temperature are:

1. Low Level or Ground Surface Inversion: Atmospheric condition in which temperature near the ground increases, rather than decreases, with elevation. Out of the different types of inversion, the ground inversion of temperature is the most important as it directly affects the society. Ground inversion occurs generally, in the tropical and subtropical areas during long winter nights only **(Fig.3.8).** The inversion of temperature in the tropical zone, however, disappears with the rise of sunrise. The duration and height of the surface inversion increase poleward. The ground surface inversion occurs under the following geographical conditions:

(i) long winter nights
(ii) cloudless clear sky
(iii) dry air-low-relative humidity
(iv) calm atmosphere or slow movement of air
(v) snow covered surface

2. Upper Air Inversion: It occurs when the warm air is transported upward into the cold air due to eddies. It may be caused due to compression of the descending air as it happens in the case of subtropical high pressure belts (anticyclones).

3. Frontal Inversion: It is caused either the horizontal or vertical movement of air. The temperate cyclones are formed due to the convergence of warm westerlies and cold polar air and thus the warm air overlies the cold air. The presence of warm air above and cold air below reverses the normal lapse rate and inversion of temperature occurs.

Social Relevance of Inversion of Temperature

The inversion of temperature and its duration affects adversely the society and the economy of the region of its occurrence. Some of the important consequences of inversion are given below:

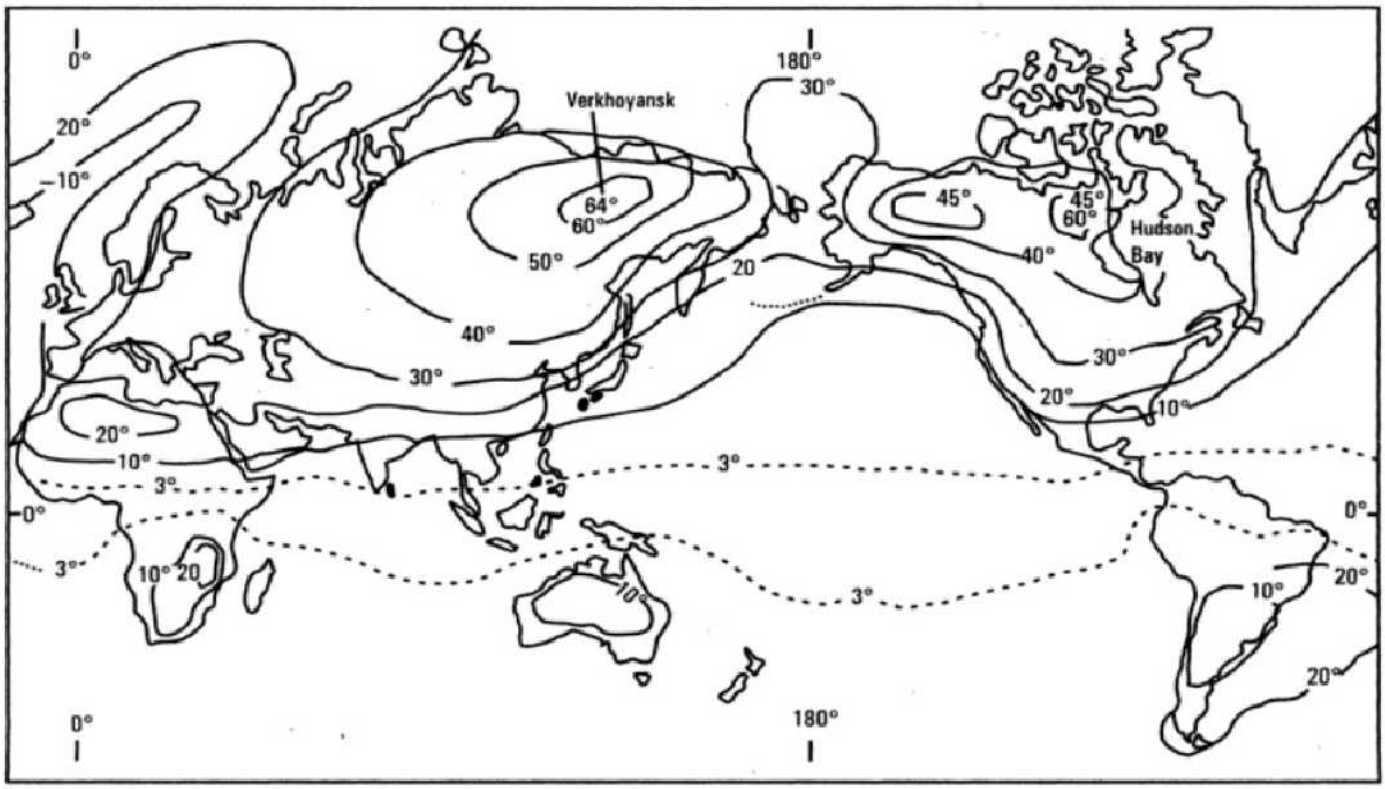

Fig. 3.7 – Annual range of air temperature

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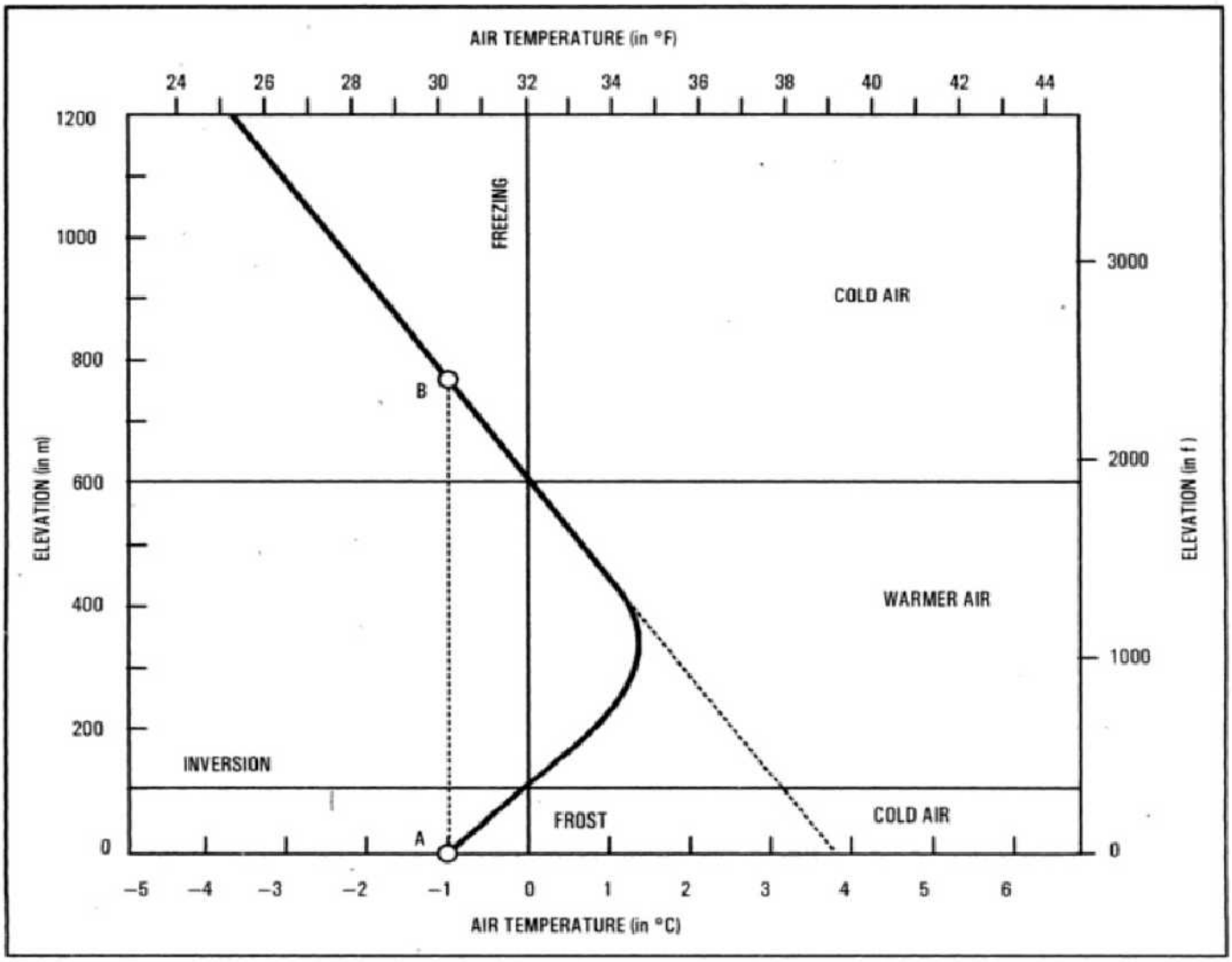

Fig. 3.8 – Low level – Inversion of temperature with frost

1. Occurrence of Fog

There develops clouds in contact with the ground (fog) with visibility usually restricted to less than 1 km. In the urban areas, the fog mixed with the smoke takes the shape of *smog*. While fog is injurious to crops, the smog is a health hazard. In 1952, in London about four thousand people died because of the urban smog. Breathing problem, asthma, and bronchitis, etc. diseases are common in Delhi especially during the winter season.

2. Accidents

At the occurrence of inversion, fog is a common phenomenon. Due to poor visibility under the foggy conditions, the frequency of road, railway, air sea-routes accidents increases. Near New Foundland, where the warm water of Gulf Stream mixes with the cold water of Labrador, there develops intense fog which is a great barrier in the movement of ships and navigation.

3. Damage to Crops

The winter crops, e.g. wheat, barley, gram, lentil (*Massoo-pulse*), mustard, peas, vegetables, chilly, potatoes, and fruit orchards are seriously damaged. The sugarcane crop of the great plains of India, especially in Western Uttar Pradesh, Uttarakhand, Punjab and Haryana develops the disease of red-rod which reduces the sugarcane content. In Brazil, and Yemen, the occurrence of fog is, however, considered

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favourable for the growth and yields of coffee. Orchards in the valley of California, Switzerland, France, Italy and Spain often get damaged due to severe fog and frost.

4. Impact on Human Settlements

In the Mediterranean region, the human settlements and location of orchards is closely influenced by the inversion of temperature. The lower parts of valleys of the Alps Mountains are almost without settlements, while the upper parts are inhabited. The upper slopes of the valleys are characterised by fruit orchards, hotels, while the lower slopes are almost deserted.

5. Inversion of Temperature and Atmospheric Stability

Inversion of temperature causes atmospheric stability which stops upward (ascent) and downward (descent) movements of air. The atmospheric stability is less conducive to rainfall.

Atmospheric Pressure

Our atmosphere is surrounded by gases. All gases have weight. The force per unit horizontal area exerted at any given level in the atmosphere by the weight of the air above that level. The atmospheric pressure is maximum at the sea level which is equivalent to about 1 kilogram per sq centimeter or 14.7 pounds per square inch. The standard air pressure at the sea level is 1013.25 millibars. The air pressure decreases most rapidly with height near sea level where the air is most dense. It decreases by about 50 per cent for every 5 km of ascent. We, however, do not feel such enormous weight on our head and shoulders because the air present inside human body exerts equal amount of outward pressure which balances the inward atmospheric pressure. Since the atmospheric pressure decreases with increasing height and, therefore, the balance between the outward pressure exerted by air of human body and inward pressure exerted by atmosphere is disturbed, with the result man suffers from nose and ear bleed at higher altitudes on the mountains.

The atmospheric pressure decreases with altitude. Moving upward from the Earth's surface, the decrease of pressure with altitude is initially quite rapid. At higher altitudes, the decrease is much slower. Because atmospheric pressure decreases rapidly with altitude near the surface, a small change in elevation will often produce a significant change in air pressure **(Fig. 3.9)**.

As atmospheric pressure decreases, the boiling point of water becomes lower. For example, the boiling point, which is 100° C at sea level, is reduced to 90°C at 3000 m. At 5000 m, the boiling point is 84°C. As the boiling point decreases, the time required to cook foods by boiling increases. At places like Leh and Kargil, boiling potatoes and pulses is a very slow process.

Pressure Gradient: The distribution of air-pressure is not uniform. Generally, pressure gradient is defined as the decrease of pressure between isobars of different values, i.e. from high pressure to low pressure. It may be mentioned that high and low pressures are always used in relative terms and not in absolute terms. More precisely, air pressure gradient refers to the rate of change of pressure per unit horizontal distance between two points. Pressure gradient denotes change of direction of air pressure which is always from high to low pressure and perpendicular to isobars **(Fig. 3.10)**. Pressure gradient is also called as *barometric slope*. Closely spaced isobars denote steep pressure gradient while widely spaced isobars are indicative of gentle or low pressure gradient. It may be mentioned that wind velocity depends on pressure gradient.

Atmospheric Circulation

The movement of air in the air is known as atmospheric circulation. When the average of the entire globe is considered, the motion is referred to as the general circulation of the atmosphere. Earth's atmospheric circulation is

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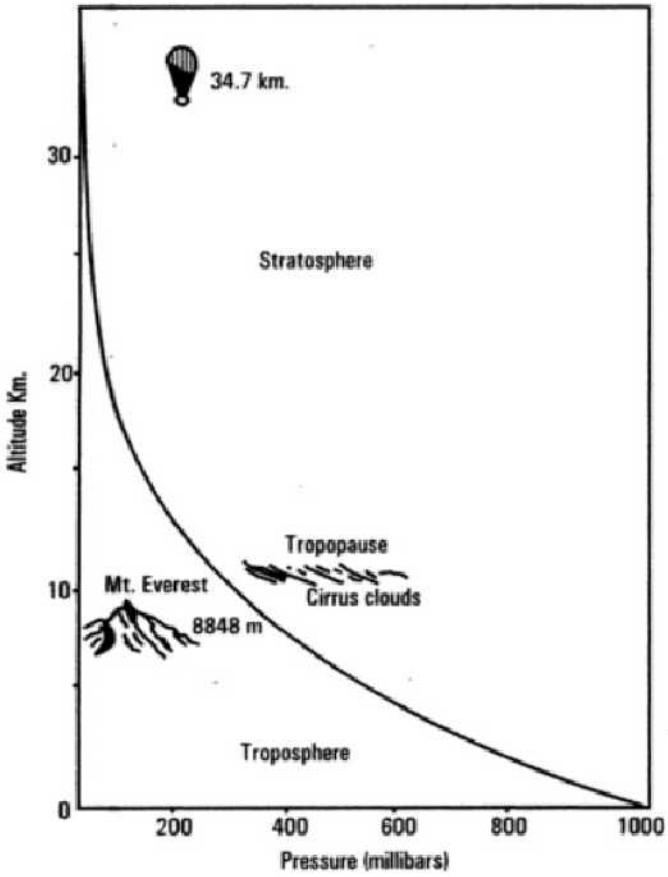

Fig. 3.9 – Atmospheric pressure decreases with increasing altitude above the Earth's surface

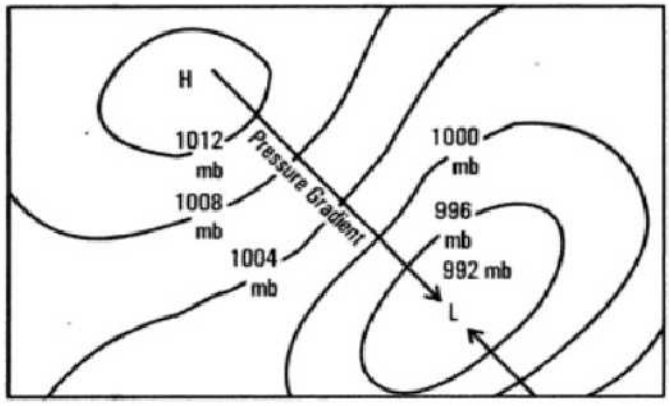

Fig. 3.10 – Pressure gradient and wind direction

an important transfer mechanism for both energy and mass. In the process, the imbalance between equatorial energy surplus and polar energy deficit is partly resolved; Earth's weather patterns are generated and ocean currents are produced.

The atmospheric circulation, speed and direction of winds are controlled by several forces. A brief description of these forces have been given in the following:

1. Gravitational Force of the Earth. The gravitational force of the Earth is practically uniform, equally compressing the atmosphere near the ground world-wide. Density of air pressure decreases as altitude increases.

2. The Pressure Gradient Force: This force drives air from areas of higher pressure to areas of lower pressure, causing wind **(Fig. 3.10)**.

3. The Cariolis Force: It is a deflective force. A deflective force appears to deflect wind from a straight path in relation to Earth's rotating surface – to the right in the Northern Hemisphere and to the left in the Southern Hemisphere **(Fig. 3.11)**.

4. The Friction Force: The friction force drags on the wind as it moves across surfaces; it decreases with height above the surface. The effect of surface friction extends to a height of about 500 m and varies with surface texture, wind speed, time of day and year, and atmospheric conditions. Rougher surfaces produce more friction. All four of these forces operate on moving air and water and affect the circulation pattern of global winds **(Fig. 3.12)**.

Direction of Winds

Winds are named for the direction from which they come. A wind blowing from east to west is an *east wind*, while a wind blowing from west to east is a *west wind* **(Fig. 3.13)**.

Geostrophic Winds (Rossby Waves)

Geostrophic winds are the winds moving between pressure areas along the paths that are parallel to the *isobars*. In the upper troposphere the pressure gradient force equals the Coriolis force so that the amount of deflection is proportional to air movement **(Fig. 3.14)**. Geostrophic winds are characteristics of upper tropospheric circulation (usually above

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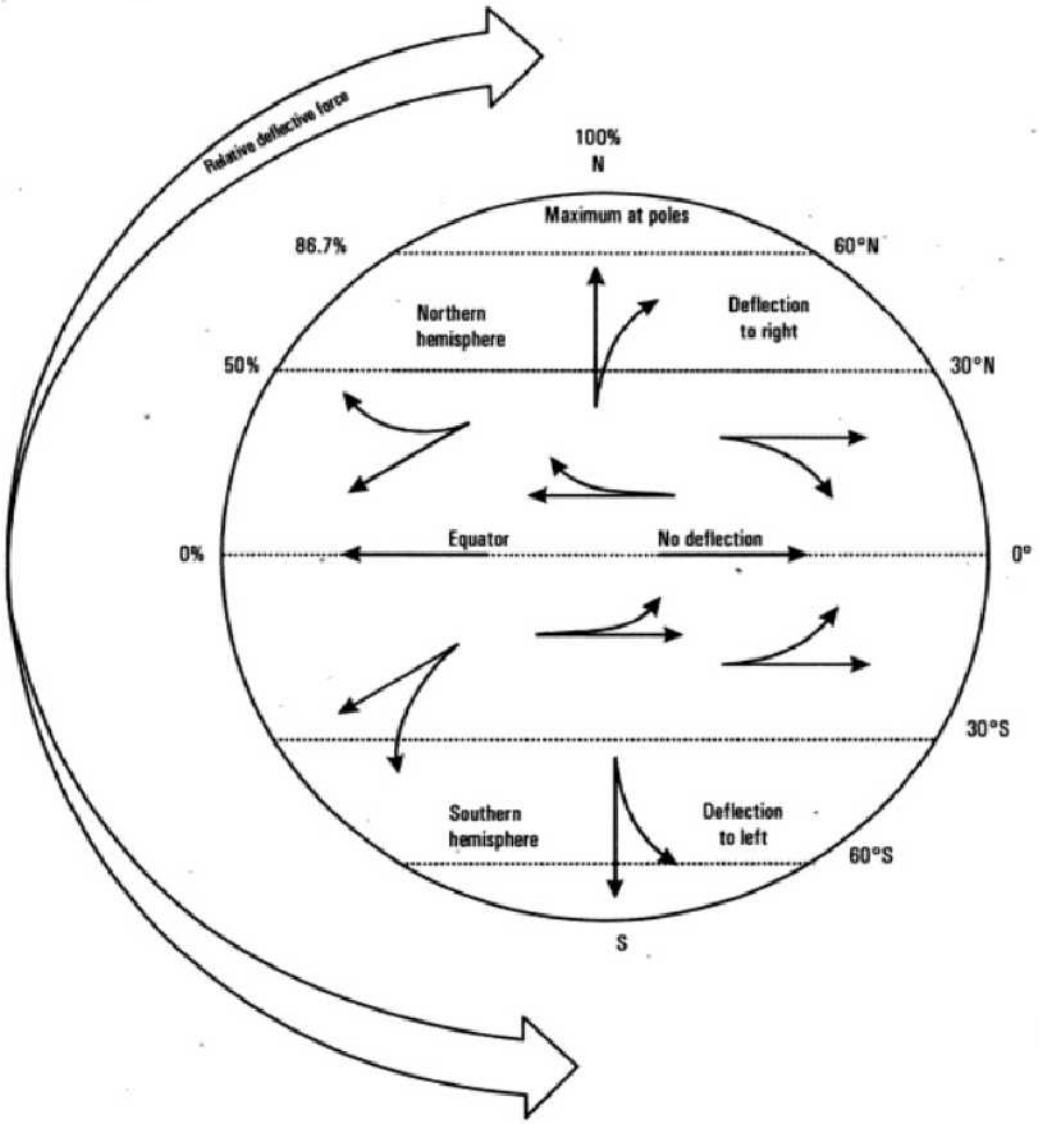

Fig. 3.11 – The Coriolis effect acts to deflect the paths of winds or ocean currents to the right in the northern hemisphere and to the left in the southern hemisphere as viewed from the starting point

500 meters). The geostrophic air blows parallel to the isobars. In other words, the air does not flow directly from high to low pressure, but around the pressure areas instead, remaining parallel to the isobars and producing the characteristic pattern. In the upper troposphere the pressure gradient force equals the coriolis force so that the amount of deflection is proportional to the air movement.

In other words, the geostrophic winds occur when the force exerted on the air by the pressure gradient is equal to the opposing coriolis force (assuming straight or nearly straight isobars, when the isobars are strongly curved, the effect of centrifugal force should be added in). The net result is a wind blowing parallel to the isobars, with speeds proportional to the pressure gradient. Except in low latitudes, where the coriolis force is minimal, the actual wind is the same as that of the geostrophic wind.

Horizontal Distribution of Air Pressure

There is a high degree of variation in the distribution of air pressure. In all, there are seven pressure belts on the globe. On the basis of mode of genesis pressure belts are divided

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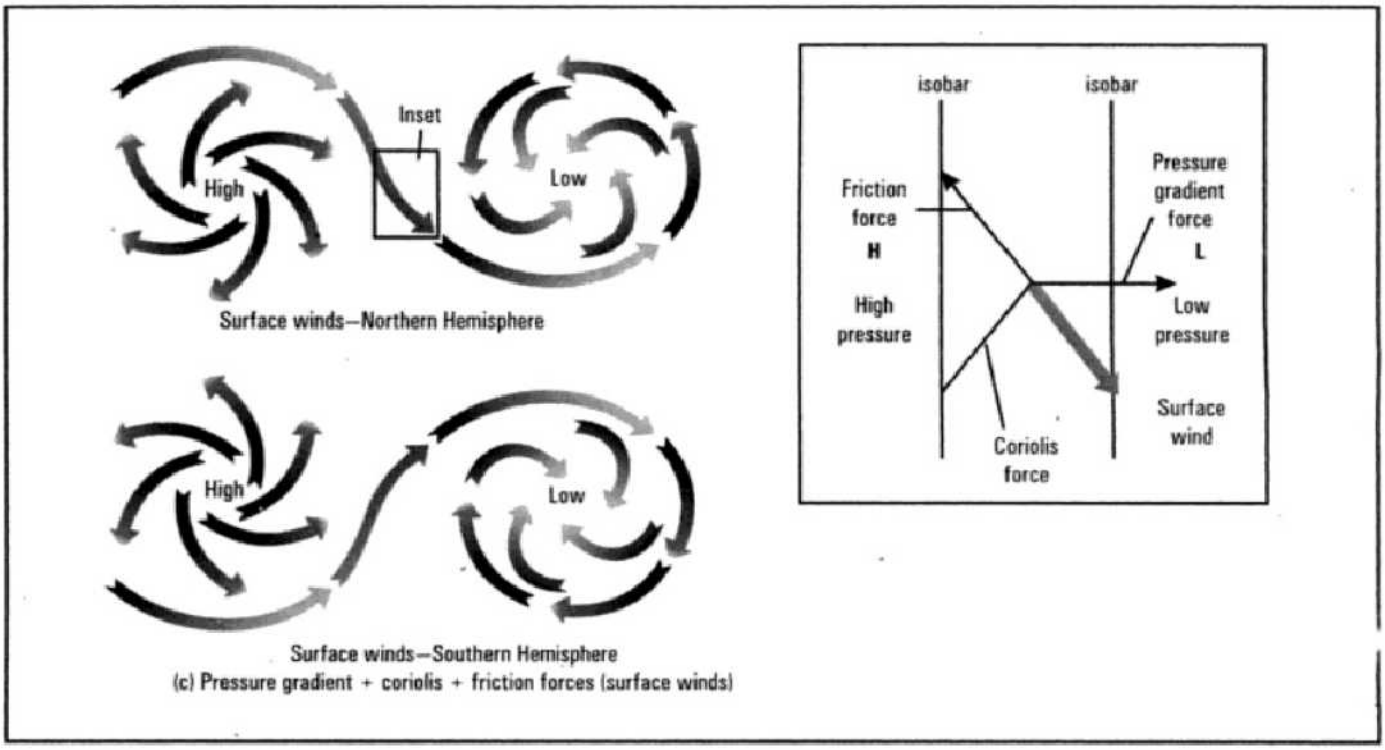

Fig. 3.12 – Effect of friction force and coriolis force

into two broad categories, i.e. (i) the Low Pressure Belts, and (ii) the High Pressure Belts **(Fig. 3.15)**. A brief description of the pressure belts is given below:

1. Equatorial Low Pressure Belt: The equatorial low pressure belt is located on either side of the geographical equator. This belt is also known as 'Doldrum' in which the air ascends upward. It extends between 5°N and 5°S latitudes. This low pressure belt is however, not stationary and shifts north and south with the change in seasons **(Fig.3.15)**.

2. Subtropical High Pressure Belt: The subtropical high pressure belts are located 25°-35° in both the hemispheres. These high pressure belts are dynamically induced. The convergence of winds at higher altitudes above this zone results in the subsidence of air from higher altitudes. Thus, descent of winds results in the contraction of air volume, increase density, and ultimately cause high pressure **(Fig. 3.15)**.

3. Sub-Polar Low Pressure Belt: The belt of sub-polar low pressure is located between 60°-65° latitudes in both the hemispheres. This low pressure belt is dynamically induced. From the polar high pressure areas, the surface air spreads outward due to rotation of the Earth, resulting into low pressure belts. In the Northern Hemisphere, these low pressure belts are found mainly along the Aleutian Islands in the Pacific Ocean and between Greenland and

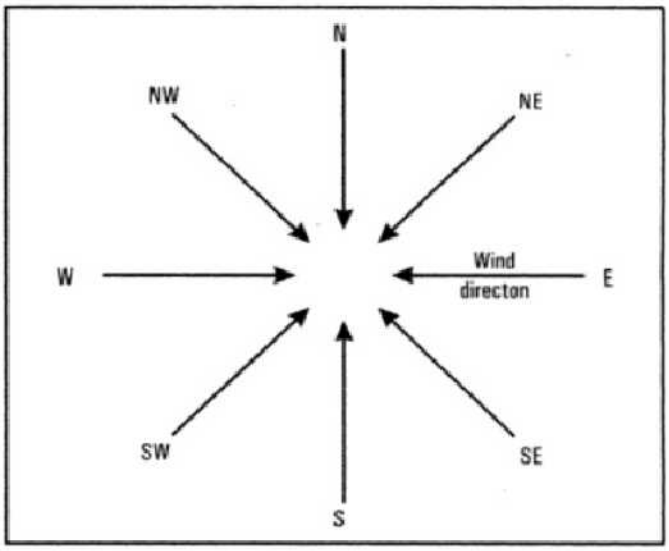

Fig. 3.13 – Winds are designated according to the compass point from which the wind comes. An east wind comes from the east, but the air is moving westward

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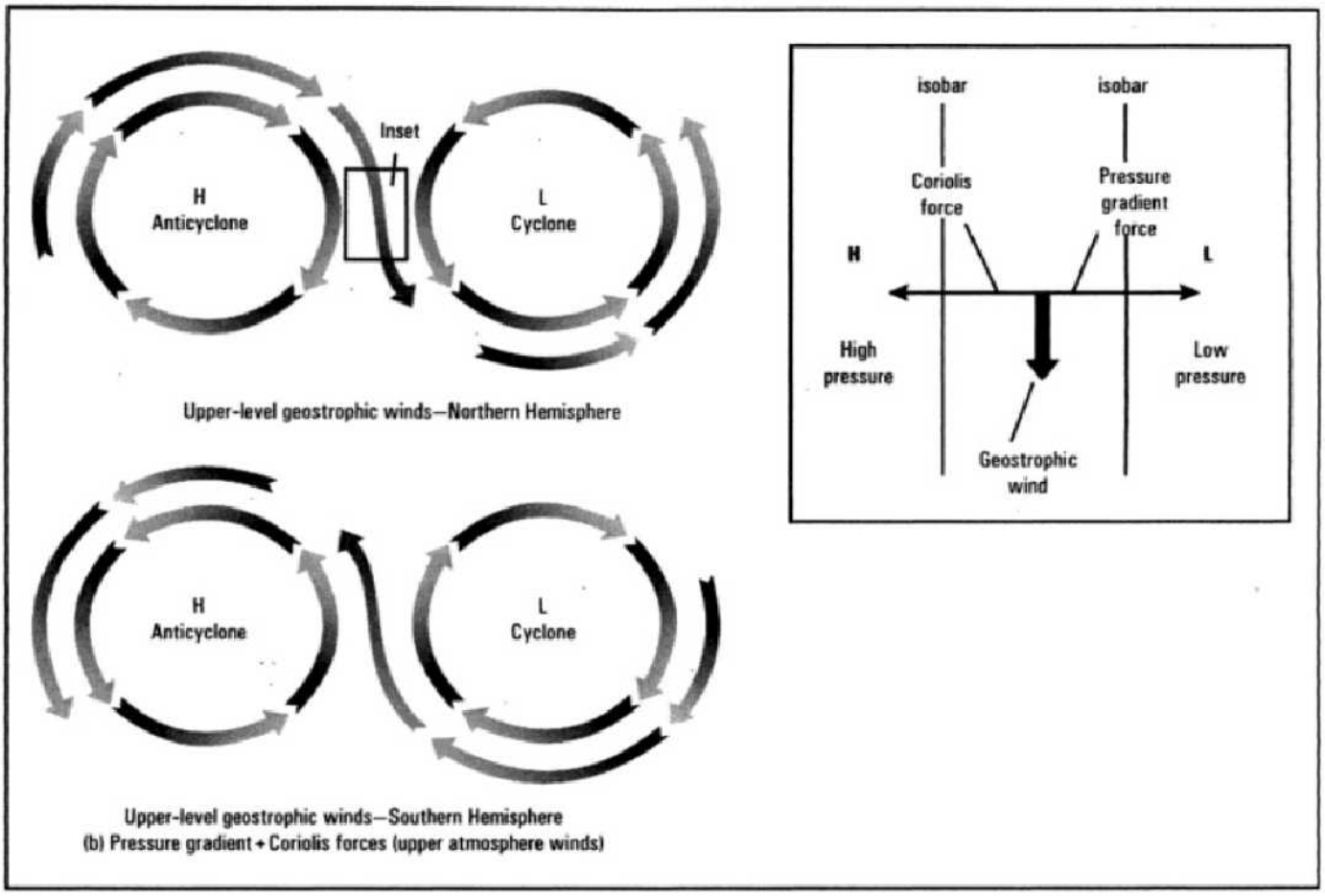

Fig. 3.14 – Geostrophic wind (After R.W.Christopherson, 1995)

Iceland in the Atlantic ocean. This belt is, however, contiguous and more persistent in the Southern Hemisphere **(Fig.3.15)**.

4. Polar High Pressure Belts: High pressure is found at the poles throughout the year. The polar regions receive little energy to put it into motion. The variable cold dry winds moving away from the polar region are anti-cyclonic (clockwise), descending and diverging in the Northern Hemisphere (counterclockwise in the Southern Hemisphere) and forming weak, variable winds called *polar easterlies*. Of the two polar regions, the Antarctic high pressure is significant in terms of strength and persistence. In the Arctic, a polar high-pressure is less pronounced, and when it does form, it tends to locate over the colder northern continental areas in winter (Canadian and Siberian highs) rather than directly over the relatively warmer Arctic Ocean **(Fig. 3.15)**.

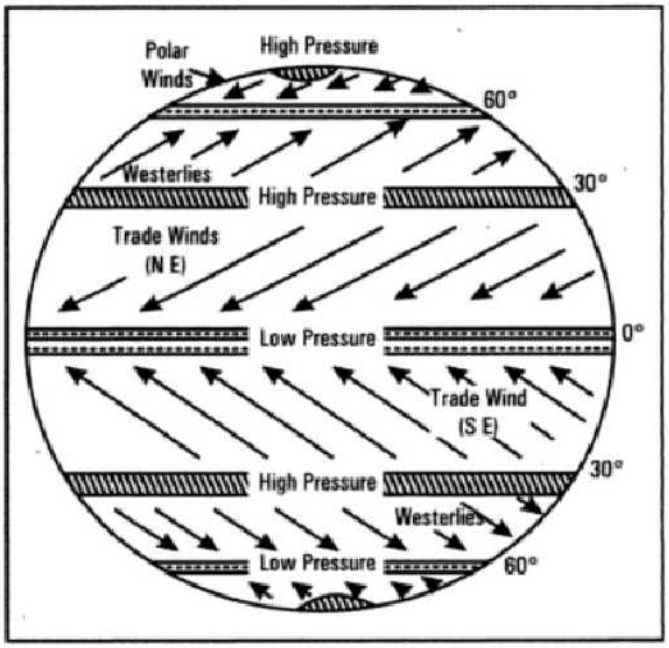

Fig. 3.15 – Air–pressure and wind belts

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Shifting of Pressure Belts

The seven pressure belts described above, seldom remain stationary in their latitudinal zones. There are daily, seasonal and annual change in air pressure because of northward and southward movement of the Sun (summer and winter solstices); contrasting nature of the heating, and cooling of land and water surfaces. The lowest pressure, generally develops between 2 and 4 p.m. due to maximum temperature, while the highest pressure is recorded between 4-6 a.m. due to minimum temperature.

All the pressure belts move northward with the northward movement of the Sun during the summer solstice when the Sun's rays are vertical at the Tropic of Cancer. On the other hand, all the pressure belts move southward during the winter solstice when the Sun is vertical at the Tropic of Capricorn. The pressure belts occupy their normal ideal position at the vernal equinox (21st March) and autumnal equinox (23rd September) when the Sun is vertical at the equator. Seasonal shifting of pressure belts has been shown in **Fig. 3.16.**

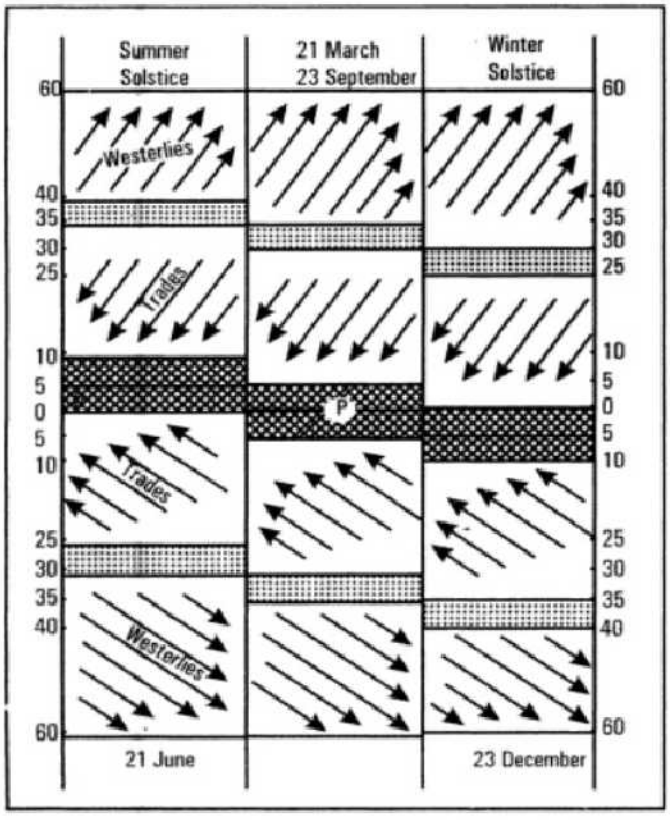

Fig. 3.16 – Shifting of pressure and wind belts

The seasonal shifts in the location of pressure belts has great climatic and weather significance. The seasonal shifting of pressure belts and winds introduce changes in the weather conditions of transitional zones and give birth to certain typical climates, namely Monsoon climate, Mediterranean climate, and West European climate, etc.

Average Conditions of Air Pressure

The average conditions of air pressure during January and July have been shown in **Figs. 3.17-A and 3.17-B**. The pressure shown in these figures are the averages of over 30 years. They are corrected for the elevation of the recording station, so that pressures are shown for sea level. The average barometric pressure is about 1013 mb. Values greater than that are *'high'* (red lines), while those lower are *'low'* **Fig. 3.17.**

July Patterns of Air Pressure

The month of July is the period of summer in the Northern Hemisphere. In the month of July, there are several areas having low pressures especially the Central Asia, Siberia, the Northen Plains of India, and the western parts of North America. On the oceans, high pressure is recorded around the Hawaiian Islands (Pacific Ocean) and the Sea of Azores (North Atlantic Ocean). In the month of July, all the high pressure cells develop over the ocean in both the hemispheres **(Fig. 3.17-A).**

January Patterns of Air Pressure

It may be observed from **Fig. 3.17-B** that in the month of January, the equatorial low pressure is found in a narrow zone south of the equator. The subtropical high pressure belt has been pushed southward. In the month of January high pressure is recorded in Siberia and Canada, and the low pressure along the Aleutian Islands and in the vicinity of Iceland. The higher latitudes of the Southern Hemisphere record high pressure.

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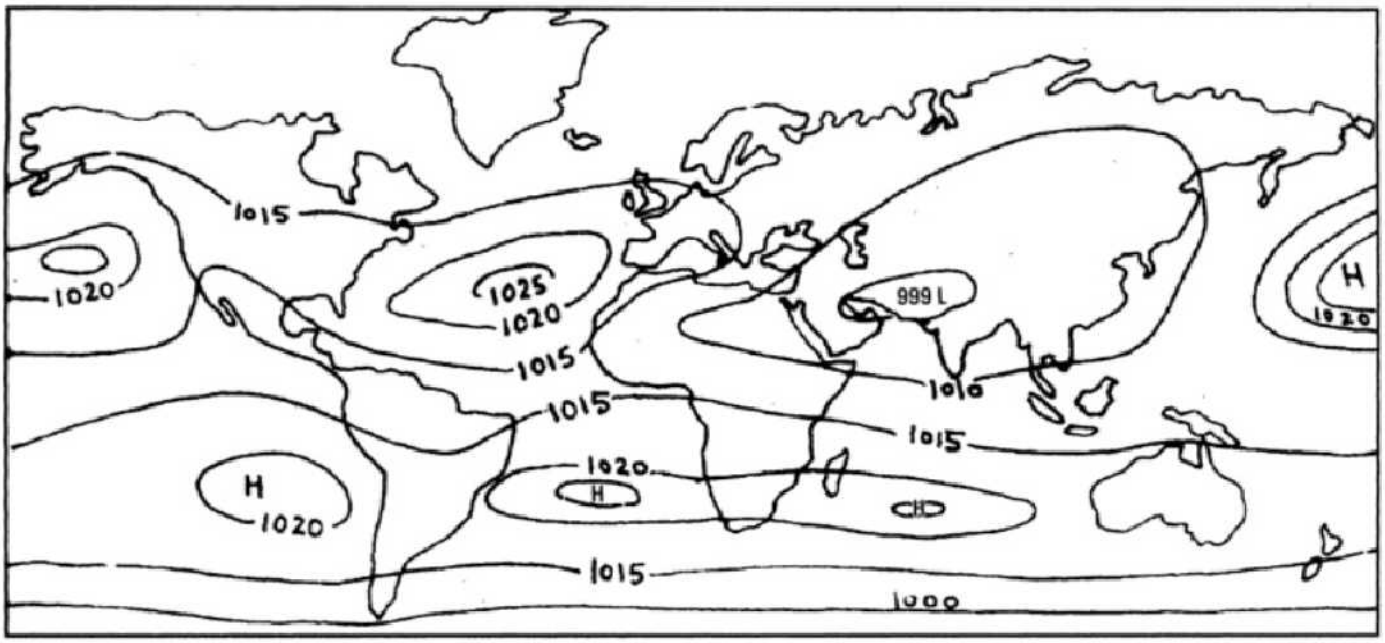

Fig. 3.17 A – Distribution of air pressure in July (Figures in millibars)

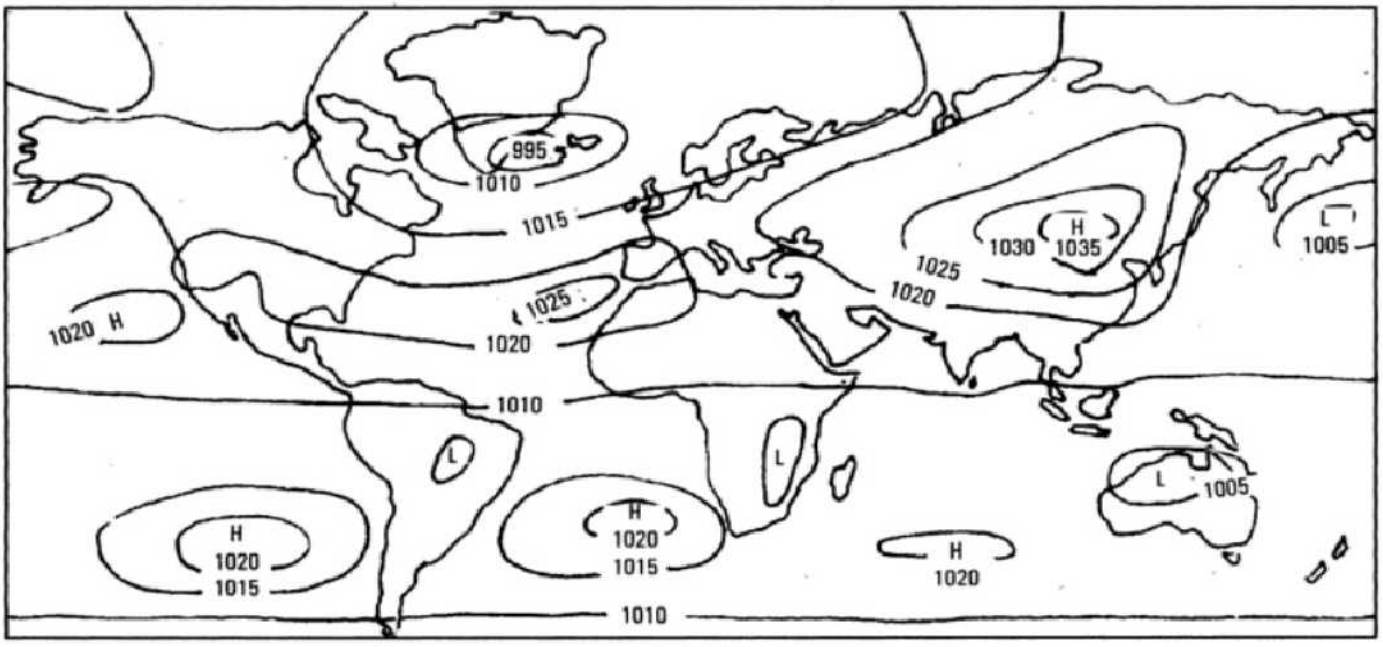

Fig. 3.17 B – Distribution of air pressure in January (Figures in mb)

Meridional Circulation

Air does not simply flow from equator to the poles, it circulates in giant cells known as Hadley and Ferrel cells. As air warms in the equatorial region (Doldrum), it expands, becoming less dense and rises. The ascending air cools and condenses, causing heavy rainfall in the equatorial region. This cool air then sinks, forming high pressure belts in the subtropics. At surface level in the tropics, these sinking currents are deflected poleward as the westerlies and toward the equator as the trade winds (easterlies). In the polar regions, they become the polar easterlies.

The concept of meridional circulation of atmosphere was put forward by *George Hadley in 1735*. He based the model on the basic

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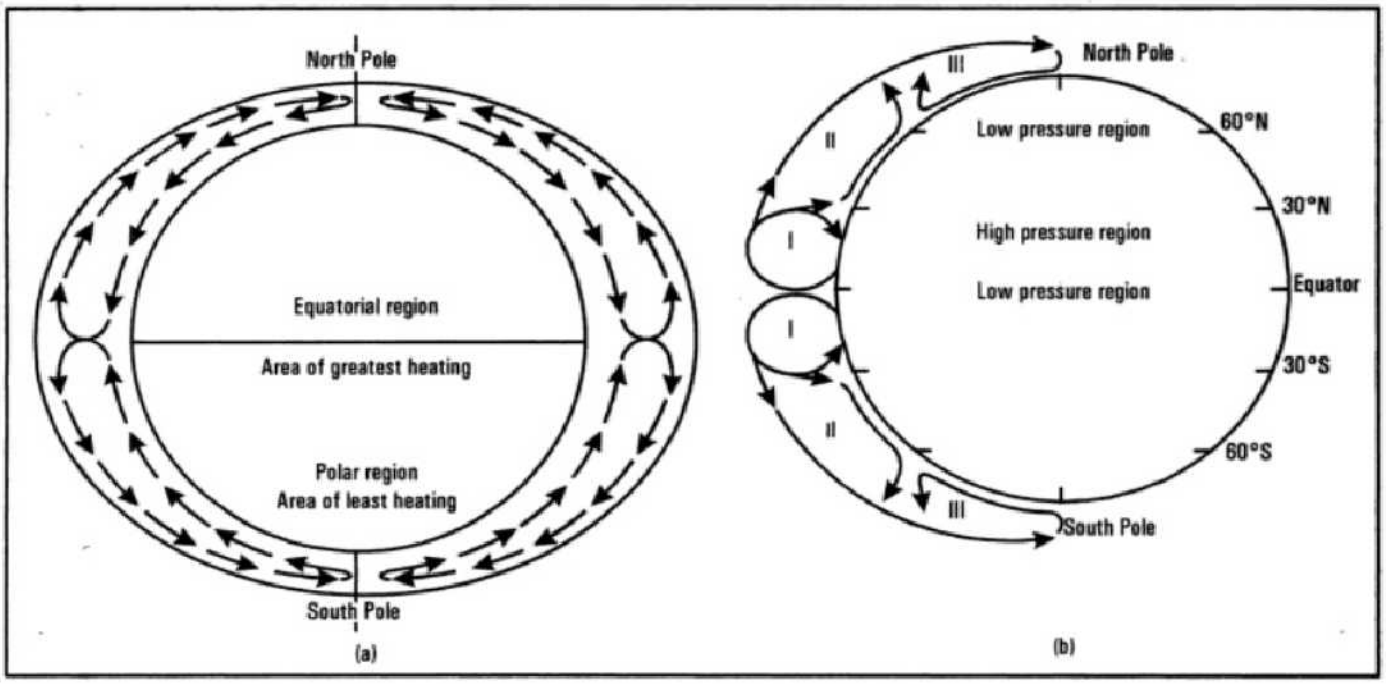

Fig. 3.18 – (a) The fundamental driving mechanisms of the general circulation (b) A three–cell model that results from differential heating, the earth's rotation, and the fluid dynamics of the atmosphere

pressure differences brought about by uneven heating of the Earth's surface. Hadley postulated that cold air descended at the poles and flowed along the Earth's surface toward the warmer equator. This flow will be countered by rising warm air at the equator and a flow aloft toward the poles so that two large Hadley cells existed in each hemisphere **(Fig. 3.18-a)**.

Observation of global wind patterns and, later, theoretical work showing that the rotation of the Earth prevents the development of a single convective cell led to a modified view. Hadley's model was altered by *Palmen in 1951* to include a three-cell structure between the poles and the equator. In the opinion of Palmen there are the following three cells in each hemisphere **(Fig. 3.18 –b)**.

Tropical or Hadley Cell

There is one Hadley cell in each hemisphere between roughly 30° N and S latitudes. They are known as Hadley cells in honour of George Hadley, the London lawyer and philosopher who worked out an overall scheme of wind circulation in 1735. The heated air rising near the equator in the Inter-Tropical Convergence Zone (ITCZ), flowing pole-ward aloft, descending at a latitude of 30°-40°, especially in the eastern half of the very intense subtropical high pressure areas at these latitudes, and then flowing either pole-ward or equator-ward near the Earth's surface. Because of the Earth's rotation the equator-ward moving currents are deflected towards the right and become the north-east. In the Southern Hemisphere they are deflected towards the left and therefore their direction is from south-east towards north-west **(Fig. 3.19)**.

Ferrel Cell

The mid-latitude circulation cells of each hemisphere are named *Ferrel cells* after William Ferrel, the American who discovered their inner working in mid-nineteenth century. The polar front cell is found in the mid-latitudes between 30° and 60° N and S. In these latitudes the pattern of circulation of air is just the reverse of the tropical (Hadley) cell. In this cell, the surface air flow is directed towards the pole, and because of Coriolis force, the winds blow almost from west to east **(Fig. 3.19)**.

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Polar Cell

Moreover, air that has grown cold over the poles begins moving toward the equator at the surface. Between 50° and 60° latitude in each hemisphere, this air has taken up enough heat and moisture to ascend. However, this polar air is more dense than the air in the adjacent Ferrel cell and does not mix easily with it. At high altitude, the ascending air from 50° to 60° latitudes turns poleward to complete a third circuit. These circuits are known as Polar cells **(Fig. 3.19)**.

Thus, three large atmospheric circulation cells – (i) Hadley cell, (ii) Ferrel cell, and (iii) Polar cell–exist in each hemisphere. Air circulation within each cell is powered by uneven solar heating and influenced by the coriolis effect.

Winds be classified into: (i) Permanent winds, (ii) Periodic winds, (iii) local winds, and (iv) variable winds (cyclones and anticyclones).

(i) Permanent Winds

The trade winds, anti-trade winds, and polar winds are known as the permanent winds. These winds follow a define track throughout the year.

(a) Trade Winds Easterlies

Winds with an easterly component which blow from the subtropical high pressure areas around 30° of latitude towards the equator. They derive their name from the Latin *'trado'*, meaning constant direction, and has given rise to the phrase *'to blow trade'* meaning *'to blow along a regular track'*. Although only surface winds, they are a major component in the general circulation of the atmosphere as they are the most consistent wind system on the Earth. The trade winds blow with great regularity over the oceans throughout the year **(Fig. 3.20)**.

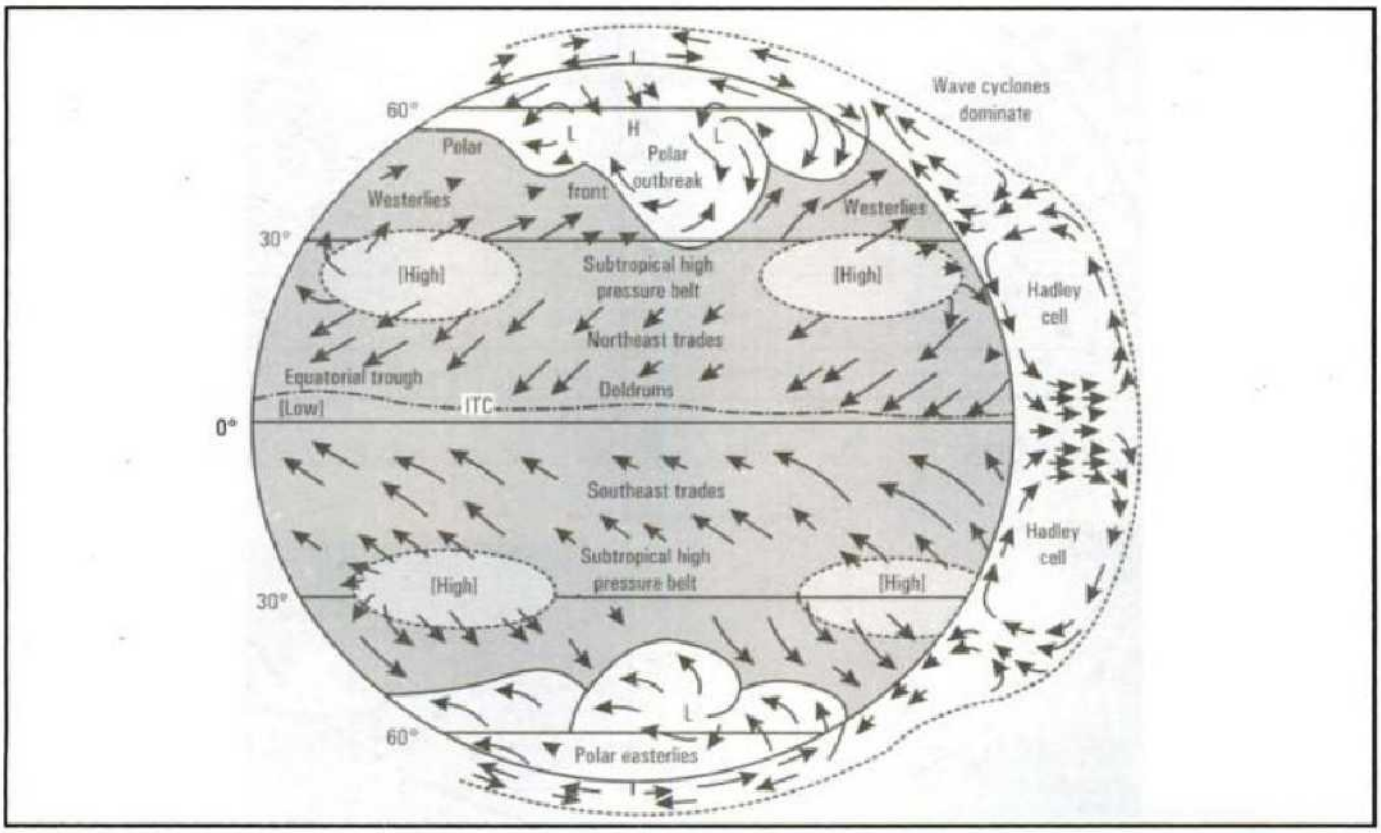

Fig. 3.19 – This schematic diagram of global surface winds and pressures shows the features of an ideal Earth, without the disrupting, effect of oceans and continents and the variation of the seasons. Surface winds are shown on the disk of the Earth, while the cross section at the right shows winds aloft

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The main function of the trade winds is to remove surplus heat from the subtropical high pressure belt by evaporating great quantities of heat from the tropical oceans. This process helps in maintaining the global heat balance. Although weather in the trade wind region is normally fine and quite, tropical cyclones are often experienced in this belt. In general the average speed trade winds varies between 15 and 30 km per hour, while calms are extremely rare and clear sunny conditions are usual.

Horse Latitudes

The subtropical high pressure belt of the Ocean of North Pacific and North Atlantic oceans is known as the horse latitudes. This is a belt of weak, variable winds and frequent calms.

Anti-Trade Winds or Westerlies

The westerly winds, which blow with great frequency and regularity in the region lying on the poleward sides of the subtropical high pressure areas or horse latitudes are known as the *anti-trade winds* or westerlies. In other words, they are the permanent winds blowing from the subtropical high pressure belts (30°-35°) to the sub-polar low pressure belts (60°-65°). The general direction of the westerlies is from south-west to north-east in the Northern Hemisphere, and from north-west to south-east in the Southern Hemisphere **(Fig. 3.20).**

The weather in the areas of the westerlies are marked by constant procession of depressions (temperate cyclones) and

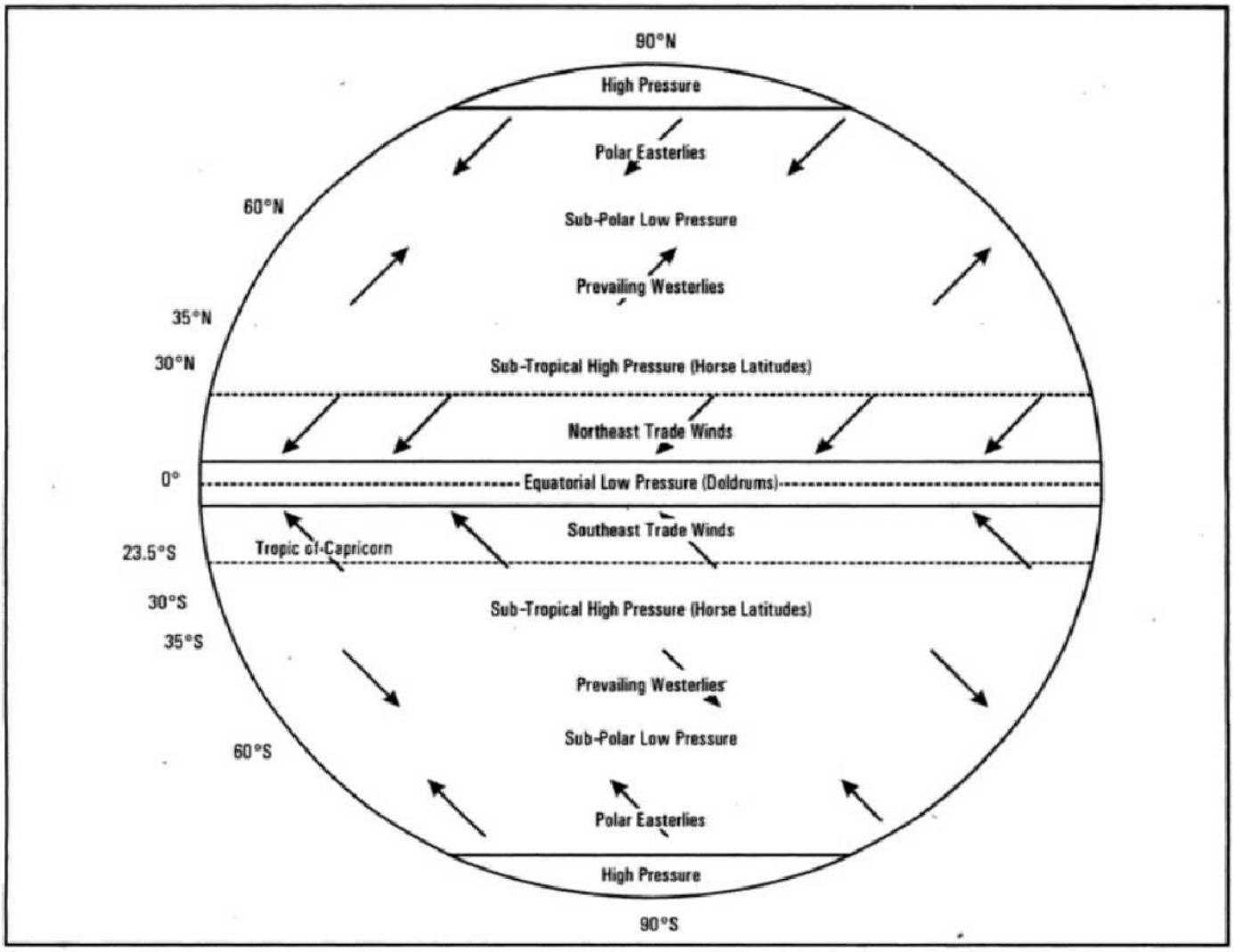

Fig. 3.20 – Major pressure belts and wind system

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anticyclones moving eastward. In the winter season, the North Atlantic Ocean is probably the stormiest region of the world at any season, but in summer, the winds and weather are much less violent. In the Southern Hemisphere, the westerlies blow with great strength throughout the year, and they have been given the name of *'roaring forties'*.

Roaring Forties

In the region between the latitudes of 40°S and 50°S the prevailing westerlies blow unobstructed by land. The westerlies in this region blows with great regularity and strength. The frequency of depressions brings storminess, cloudiness, and rough seas – a notoriously hazardous shipping zone. The westerlies in this belt are often called as roaring forties.

Polar Easterlies

The polar easterlies blow between the 60° and 90° in the polar regions. They are generally sporadic and of low velocity. From the polar areas cold air tends to move towards equator. The polar easterlies are quite pronounced in the Southern Hemisphere. In the Northern Hemisphere, pressure and wind conditions are so complicated that these polar winds are extremely irregular. Being cold and dry, polar winds give very little precipitation **(Fig. 3.20)**.

(ii) Periodic Winds - Monsoon

Derived from the Arabic word *Mausim*, meaning season, the term originally referred to the winds of the Arabian Sea, which blow for about six months from the north-east and for six months from the south-west. The term is now used for other markedly seasonal winds, e.g. the tropospheric monsoon. In the monsoon climate there is a complete reversal of wind direction after every six months, i.e. the wind blows for six months from sea towards land and six months from land towards sea **(Fig. 3.21)**.

The monsoon is the product of many factors working together. One is that the Inter Tropical Conversence Zone (ITCZ) migrates to between 25° and 30°. A second is that the land mass interior records a large change in pressure that enforces the migration of the ITCZ. It is also likely that the Himalaya mountains and the Tibetan Plateau are a very significant topographic barriers, which split the circulation over Asia.

In the winter, the jet stream is over the mountains. The polar high expands and covers much of north-central Asia. Divergence from this strong system north of the Himalayas produces extremely strong offshore surface winds. South of the Himalayas and the jet stream, the anticyclonic flow is much weaker, although offshore flow is most common. In the summer as the temperature differential over the continent diminishes, the jet stream breaks down. The subtropical high and ITCZ shifts rapidly northward and bring the sudden shift of winds onshore over the Indian subcontinent. North of the Himalyas, a weaker convergent system develops with attendant onshore flow of air.

The precipitation is primarily convectional rainfall randomly distributed within the flowing moist air. Some travelling cyclones associated with the ITCZ add further rainfall. The peak season of rainfall moves northward over the subcontinent as the zone of convergence moves northward toward the slopes of the Himalayas.

The salient characteristics of the monsoon climate are to be found mainly in the Indian Subcontinent., where over much of the region annual changes may conveniently be divided as follows:

(i) The season of north-east monsoon:

(a) January and February, winter season;

(b) March to May, hot weather season.

(ii) The season of south-west monsoon:

(a) June to September, season of general rains;

(b) October to December, season of retreating monsoon. (For a systematic description of India seasons, read *'Geography of India'* published by Tata McGraw-Hill).

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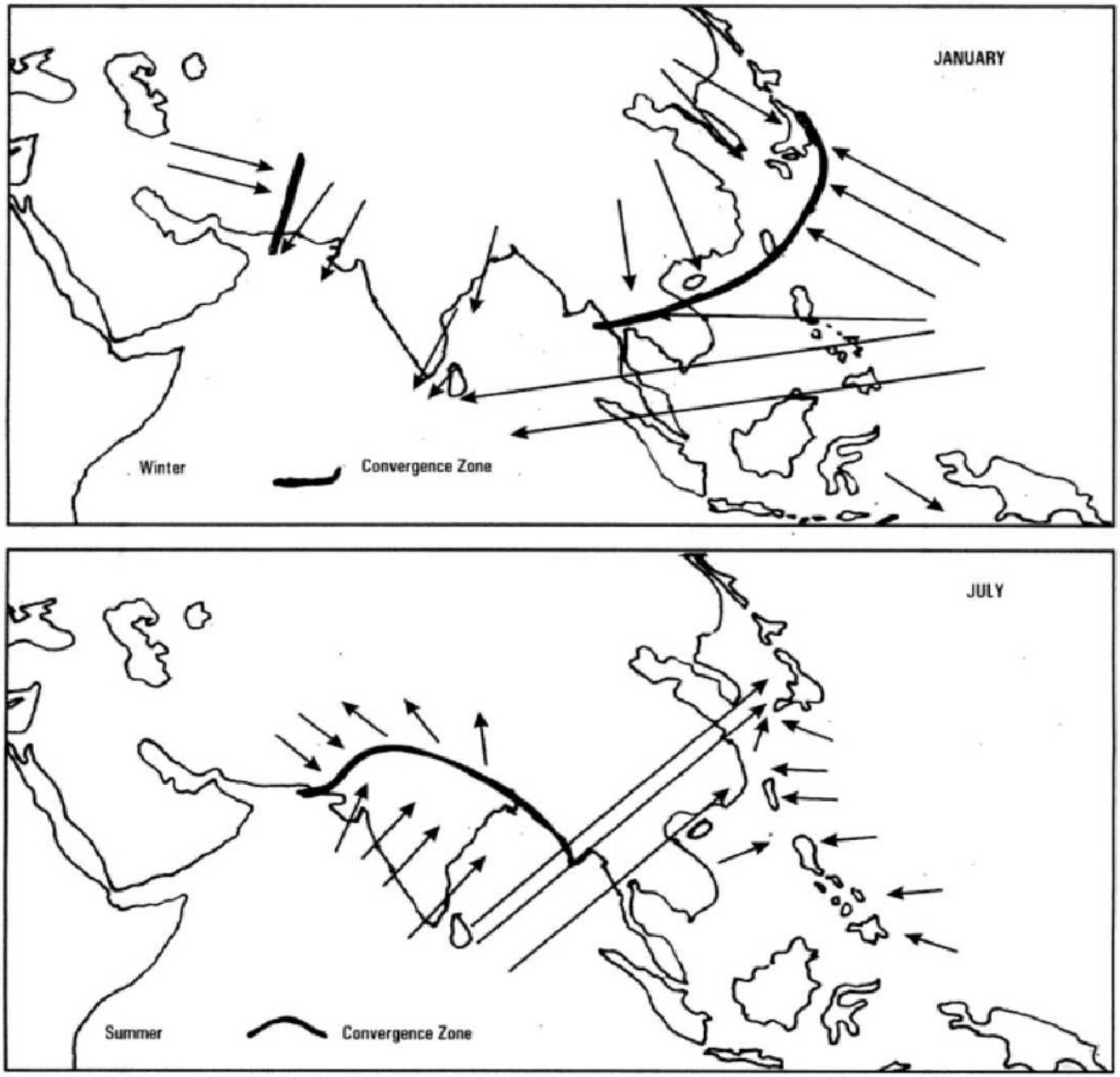

Fig. 3.21 – Winter and summer monsoons in Asia

(iii) Local Winds

Daily variations in atmospheric pressure develop in many parts of the world and lead to distinctive local wind patterns. These variations in pressure result from moving air caused by changing surface temperature through the day, and they result in daily changes in wind direction and velocity **(Fig. 3.22).** There are many locally named winds, and only selected examples have been described briefly in the following:

Sea Breeze

In the hours of sun-rise, land temperatures rise rapidly while water temperatures rise slowly. When the air overlying above the shoreline heats, it expands and its density decreases. The air rises over the land surface and cold air flows

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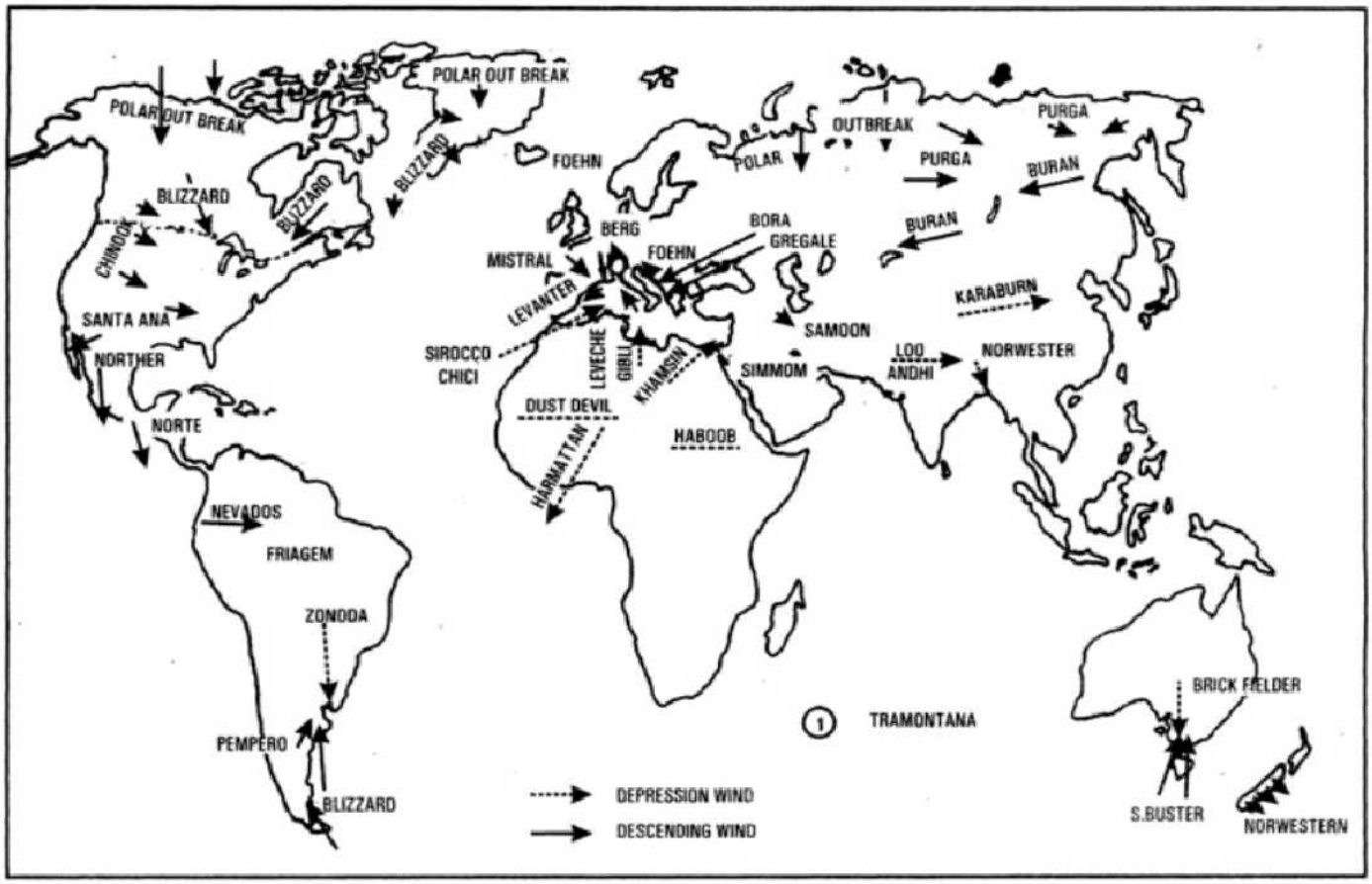

Fig. 3.22 – Main local winds of the world

in from the sea to replace it. This flow of air landward is known as *sea breeze* **(Fig. 3.23-A)**. The sea breeze casually begins several hours after sunrise, about 11 A.M. and peaks in the afternoon when temperatures are the highest. This air may penetrate inland up to 30 km or more along an ocean coast and to a lesser extent around lakes. The sea breeze is gusty and brings a decrease in temperature and an increase in humidity.

Land Breeze

A wind blowing from land to sea (an off shore wind) which develops in coastal areas towards nightfall **(Fig. 3.23-B)**. Pressure is relatively higher above the land than above the sea as the land cools more rapidly in the evening. The temperature and pressure relationships reverse with the higher pressure over the land. At night, however, the contrast between water and land is not as large as it is in the daylight hours. The water surface actually does not gain heat at night, but retains the heat acquired during the daylight period and, thus, remains relatively warm compared with the land. There is usually a lag in the development of the breeze due to the general inertia of the system. The sea breeze does not set in until well after the temperature differences develop.

The land breeze and the sea breeze have a close influence on the lives of fishermen and those who work indoor and outdoor along the coastal areas in the tropics. The fishermen go into the sea to catch fish in the early morning hours when the wind blows from land towards sea, and return to their home around mid-day when the sea breeze support their return journey. It has been observed that the efficiency of workers in the coastal areas of tropics is higher in the afternoon as compared to the forenoon period. This is mainly because the afternoon weather is pleasant and enjoyable.

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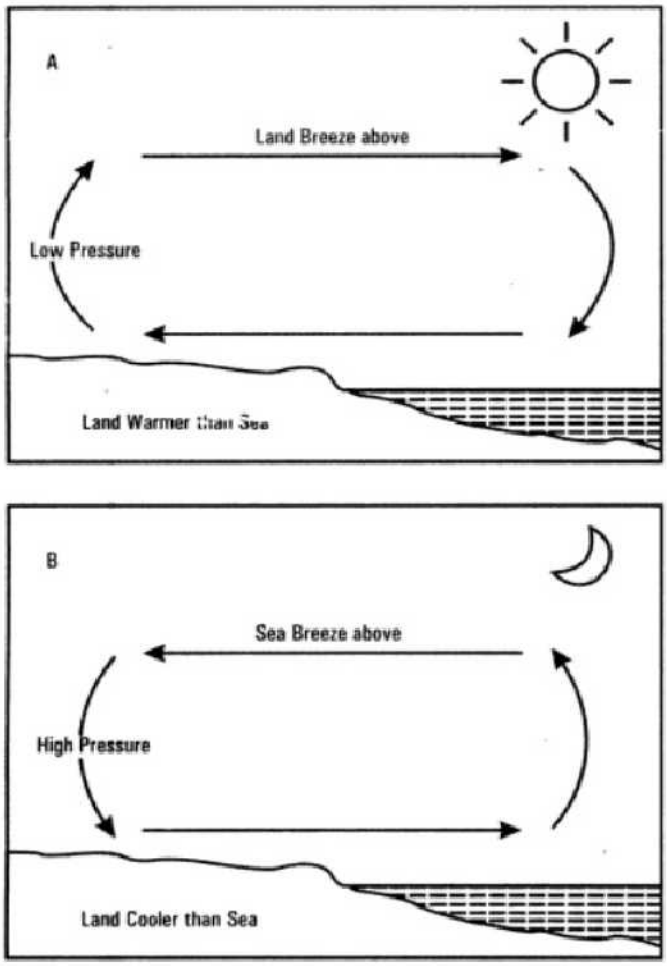

Fig. 3.23 – A– Sea-Breeze and B – Land-Breeze

Mountain and Valley Winds

There is a reversal in the direction of winds in the mountains and their valleys. These winds are known as the mountain and valley winds **(Fig. 3.24)**. In the daytime, the valley and slopes of mountains receive heat from the sun. The air near the surface heats, expands, and rises up the mountains . This breeze, called the *valley wind* for the place of origin, is a warm wind and a daytime or late afternoon phenomenon. The clouds often seen forming over the hills in the afternoon are the result of condensation taking place as the air rises to cooler heights over the mountain. At night the valley walls become cool. As the air at the surface cools, it flows down the slope due to greater density. This is the mountain wind, also known as the night breeze. In some mountain regions subject to frost, the valley slopes are the preferred places of orchards. The air moving up and down the valley slopes reduces the chance of the stagnant conditions conducive to frost formation.

Chinook Winds

Chinook is a local wind that blows on the downward slopes of Rockies. The name comes from the Chinook Red Indians, who live along the lower reaches of the Columbia River. In the language of Red Indians Chinook means 'Snow eating wind'. 'The Chinook is a relatively warm and dry wind. It develops with the uplift of relatively mild stable air ascending windward slopes of mountains. The wind develops fairly quickly with a sharp rise in temperature and a drop in relative humidity. These winds are mostly identified with the sudden change in temperature brought about by these winds. For example, in two minutes, the temperature at Spearfish in South Dakota (1943), rose from -20°C to 7°C. This was a total rise of 27°C in 2 minutes. These winds occur most often in a narrow zone about 300 kilometers east of the crest of the Rockies from New Mexico north into Canada. The form on the leeward sides of mountain ranges is shown in **Fig. 3.25.**

The primary source of heat in the Chinook is the heat of compression. Chinooks form when there is a strong westerly flow of air across the mountains. When there is a strong wind, a trough or cell of low pressure forms on the east side of the mountains. As the air is stable, the low pressure trough pulls the wind down the eastern slope of mountains to its original altitude. The subsiding air heats at the dry adiabatic rate of 10°C/kilometer.

The Chinook is strengthened if precipitation takes place in the air stream as it rises over the windward side of the mountains. Condensation adds heat to the air. When the air descends on the lee-side of the mountains, it is warmer than at the same height on the west side.

A cloud, called a Chinook wall cloud, forms over the Rockies when a Chinook is blowing. The cloud forms and remains over the mountain crests providing a visible sign of the

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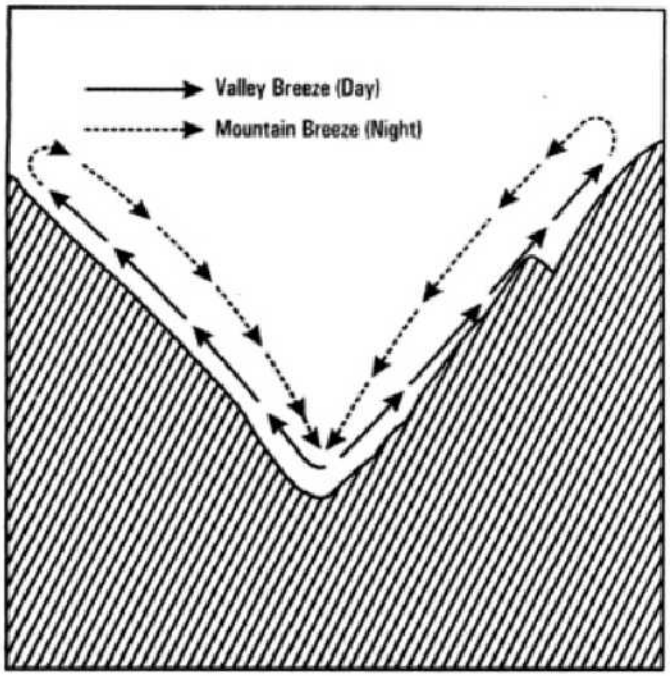

Fig. 3.24 – Mountain and valley winds

wind system. As the air descends the eastern flank of the mountains, the clouds evaporate in the warmer air and a clear sky may exist above the Chinook.

Chinook winds are gusty and can reach velocities as high as 160 km per hour. The Chinook has the capacity to absorb much water. Because they are warm and dry, in the winter they may sublimate large amounts of snow. It is not unusual for these winds to remove 15 cm (6 inch) of snow a day.

They may remove half meter of snow in a single day. It is for this reason that these winds are called *snow-eaters*. The same wind occurs in other parts of the world. It is the Foehn wind in the Alps Mountains of Europe. In Argentina, the wind is a Zonda. The main characteristics of some of the local winds have been presented in **Table 3.1**.

***Table 3.1:** Characteristics of Selected Local Winds*

Name (origin)	*Location*	*Characteristics*
Bora	Adriatic Coast	Cold, gusty, north-easterly wind. Frequency at Trieste (Italy), 36 days in one year. Mean winter speed 50 km per hr, summer 40 km per hr. The speed may reach 100 kilometers per hour in winter. Adiabatically warmed wind.
Chinook, in the language of Red Indians-*ice-eater* (from Chinook Indian Territory-USA-Canada)	Eastern slopes of Rockies	A warm wind that may, at times, result in sudden and drastic rise in temperature. May attain 10°-20°C in spring with relative humidity of 10 per cent. Predominant in spring. Adiabatically warmed wind.
Etesian (Gr. Etesia, annual)	Eastern Mediterranean	Cool, dry, north-easterly wind that recurs annually. Summer and early autumn. Associated with regional low pressure system.
Fohn German, possibly from Latin *favonium, meaning* =favouring wind)	Alpine lands (Also in Santa Ana, Southern California)	Similar to Chinook. Characterised by warmth and dryness. Most frequent in early spring.
Haboob (Arabic)	Southern margin of Sahara (Sudan)	Hot, damp wind often containing sand and dust. Of relatively short duration (3 hrs). Average frequency of 24 per year. Early summer with the advance of the ITCZ.

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Harmattan	West Africa	Hot, dry wind, characteristically dust laden. All year, but most notable in the winter season. Associated with air flow from the Sahara desert. It is also known as doctor as it reduces the relative humidity in the coast countries of Gulf of Guinea.
Khamsin (Arabic)	North Africa and Arabia	Hot, dry, south-easterly wind. Regularly blows at a 50-day period (Khamsin=50). Temperature varies between 40°-50°C. Same wind with adiabatic modifications includes *Gibli* (Libya), *Sirocco* (Mediterranean), *Leveche* (Spain). Late winter, early spring. Regional low pressure systems.
Levanter (from Levant, eastern mediterranean	Western mediterranean)	Strong easterly wind often felt in the Straits of Gibraltar and Spain. Damp, moist sometimes giving foggy weather for perhaps two days. Fall, early winter to late winter, spring. Regional low pressure systems.
Mistral (master wind)	Rhone Valley below Valence	Strong, cold wind channeled down Rhone Valley. May reach a speed of 100 km per hour. It can cause sudden chilling in coastal regions. (Note also the *Bise*, and equivalent cold north wind in other parts of France.) Most frequent in winter. Regional low pressure systems.
Norther	Texas, Gulf of Mexico to W. Caribbean	Cold, strong, northerly wind whose rapid onset may suddenly drastically lower temperatures. Frequent in winter. Related to circulation pattern over the USA.
Pampero	Pampas of South America	Southern Hemisphere equivalent of the Norther. Winter. Related to large scale pressure patterns.
Zonda	Argentina	A warm, dry wind on lee of the Andes. Can attain 120 kilometer per hour. Comparable to *Chinook* and *Fohn*. In dry weather, carries much dust. Winter.

Source: John, E. et.al., 2002, **Climatology–An Atmospheric Science**, *Low Price, 2nd edn. Delhi, Pearson Education, pp.98-99.*

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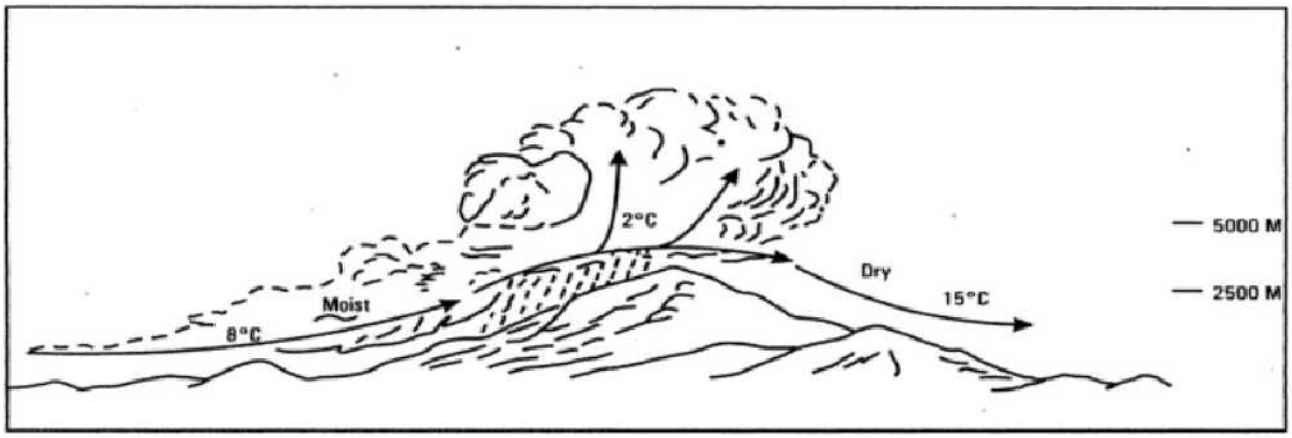

Fig. 3.25 – Chinook or Fohn wind

(iv) Variable Winds

The winds which change their direction after every few hours are known as variable winds. Variable winds include (i) cyclones, and (ii) anticyclones.

Cyclones

Any rotating low pressure system is known as a cyclone. In other words, a thermally or dynamically caused low pressure area of converging and ascending air flows is known as a cyclone. The cyclones may be classified under two headings: (i) temperate cyclone, and (ii) tropical cyclone.

Temperate Cyclone

The temperate cyclones occur in the mid-latitudes of both the hemisphere. These cyclones are born along the polar front, particularly in the region of Icelandic and Aleutian sub-polar low-pressure areas in the Northern Hemisphere.

Fronts

The leading edge of an advancing air mass is known as a front. It is a line of contrasting weather conditions. Fronts may be classified in the following three categories:

Cold Front

The leading edge of a cold air mass, identified on a weather map as a line marked with a series of triangular spikes, pointing in the direction of frontal movement **(Fig. 3.26).**

Warm Front

The leading edge of an advancing warm air mass, which is unable to push cooler, passive air out of the way; tends to push the cooler, underlying air into a wedge shape; noted on weather maps with a series of rounded knobs placed along the front in the direction of the frontal movement **(Fig. 3.26)**.

Occluded Front

In a cyclonic circulation, the overrunning of a surface warm front by a cold front and the subsequent lifting of the warm air wedge off the ground; initial precipitation is moderate to heavy **(Fig. 3.26).**

Cyclogenesis

Development and strengthening of mid-latitude wave cyclone is known as cyclogenesis. On the average, a temperate cyclone takes 3-10 days to progress through the stages of

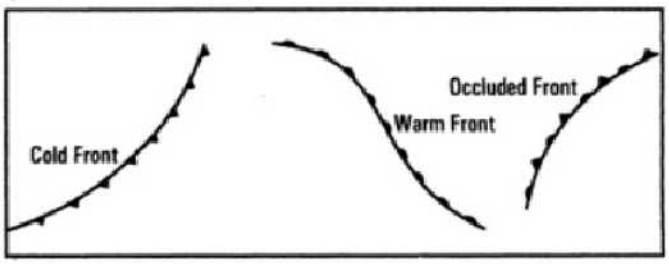

Fig. 3.26 – Types of fronts

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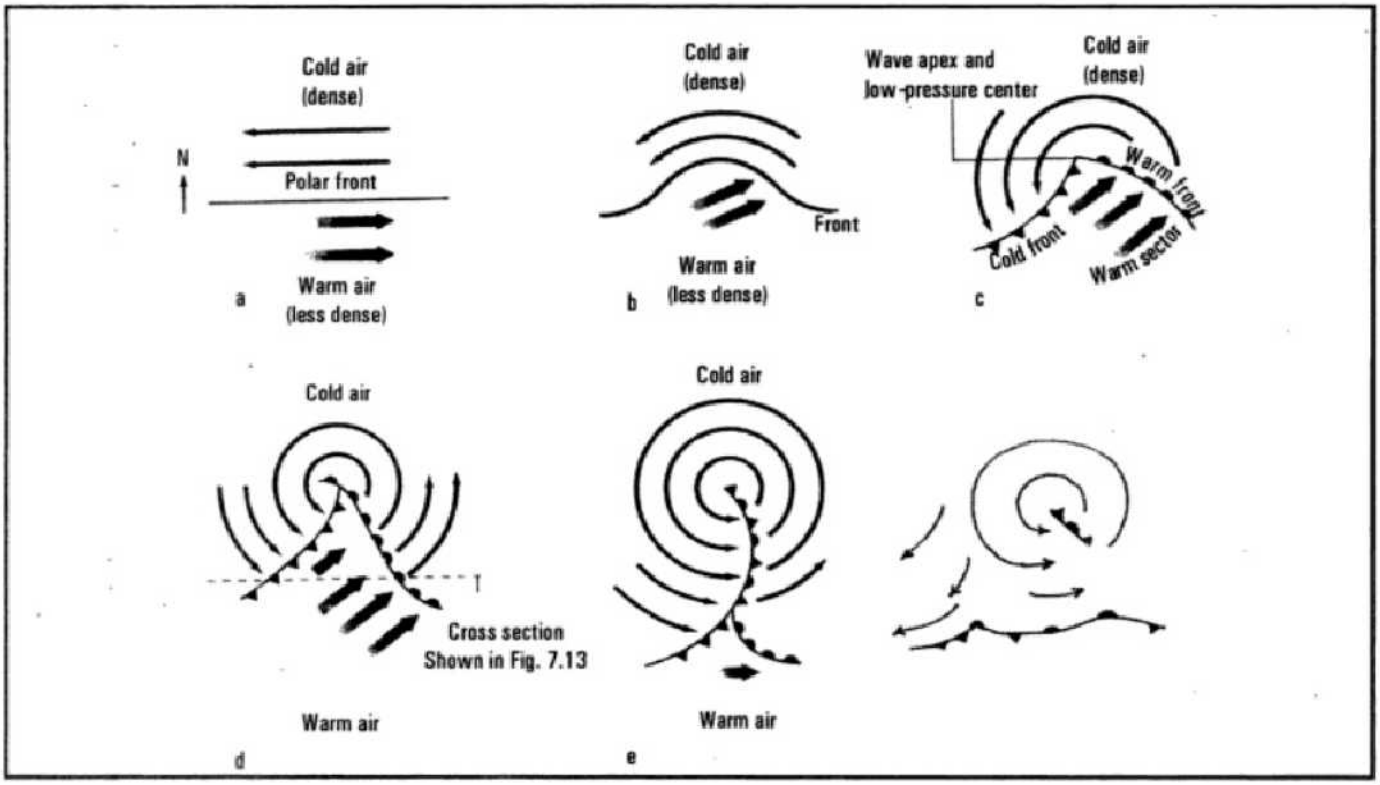

Fig. 3.27 – Origin of extra tropical cyclone (after T. Garrison, Oceanography, 1995, p.125)

development. Along the polar front, cold and warm air masses converge and conflict. The polar front forms a discontinuity of temperature, moisture and winds that establishes potentially unstable conditions.

Polar Front Theory (Frontal Theory)

The polar front theory about the origin of temperate cyclones was put forward by V. Bjerknes and J. Bjerknes in 1918. The period of cyclone from its inception (cyclogenesis) to its termination (frontolysis or occlusion) is called the 'life cycle of cyclone' which is completed through six successive stages **(Fig. 3.27).**

Stage I: The first stage involves the convergence of two air masses of contrasting physical properties and directions.

Stage II: It is called the *'incipient stage'* during which the warm and cold air masses penetrate into the territories of each other.

Stage III: It is mature when the cyclone is fully developed and isobars become almost circular.

Stage IV: Warm sector is narrowed in extent due to the advancement of cold front at a faster rate than warm front, and cold front comes nearer to warm front.

Stage V: This stage starts with the occlusion of cyclone when the advancing cold front finally overtakes the warm front and occluded front is formed.

Stage VI: In the final stage (VI) warm sector completely disappears, occluded front is eliminated and ultimately cyclone dies out **(Fig. 3.27).**

Characteristics of Temperate Cyclones

(i) The mid-latitude, the temperate cyclone moves in a counter clockwise direction in the Northern Hemisphere and clockwise in the Southern Hemisphere.

(ii) The temperate cyclone may be 1600 km wide, thus a single cyclone may cover the whole of Europe.

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(iii) The isobars are elliptical in shape.

(iv) The cold air-mass moves faster than the warm air mass.

(iv) These cyclones move at a gentle pace of 5 to 25 km per hour.

(v) They give light showers which are highly beneficial for the crops and human health and efficiency.

(vi) In the ending part of the cyclone there is thunder and lightning.

(vii) Each cyclone is followed by clear weather (anticyclone).

Weather Associated with Temperate Cyclones

The weather conditions in different parts of the cyclone vary significantly. Before the arrival of a temperate cyclone, air pressure decreases, the Sun and the Moon are generally encircled with *halo*, the high wispy cirrus clouds appear first on the western horizon. Temperature increases suddenly when the cyclone comes very close to the observation point, wind direction changes from easterly to south-easterly. Subsequently, the cloud cover thickens and the sky becomes overcast with dark, thick and low clouds, mainly nimbostratus clouds.

Clouds become very thick and dark with the arrival of warm front of the cyclone and heavy shower begins with nimbostratus clouds. Since the warm air rises slowly along the front, the precipitation is also gradual, but of long duration. The Sun is not visible for several hours. In the region of warm front, precipitation is characterised by foggy air and poor visibility. In winter, ice pellets or freezing rain may occur when rain falls from the warm air through the cold air-mass below **(Fig. 3.28)**. At the advent of the cold front, temperature registers marked decrease with the arrival of cold front. The cold air pushes the warm air upward and there is change in wind direction from south-westerly and westerly direction.

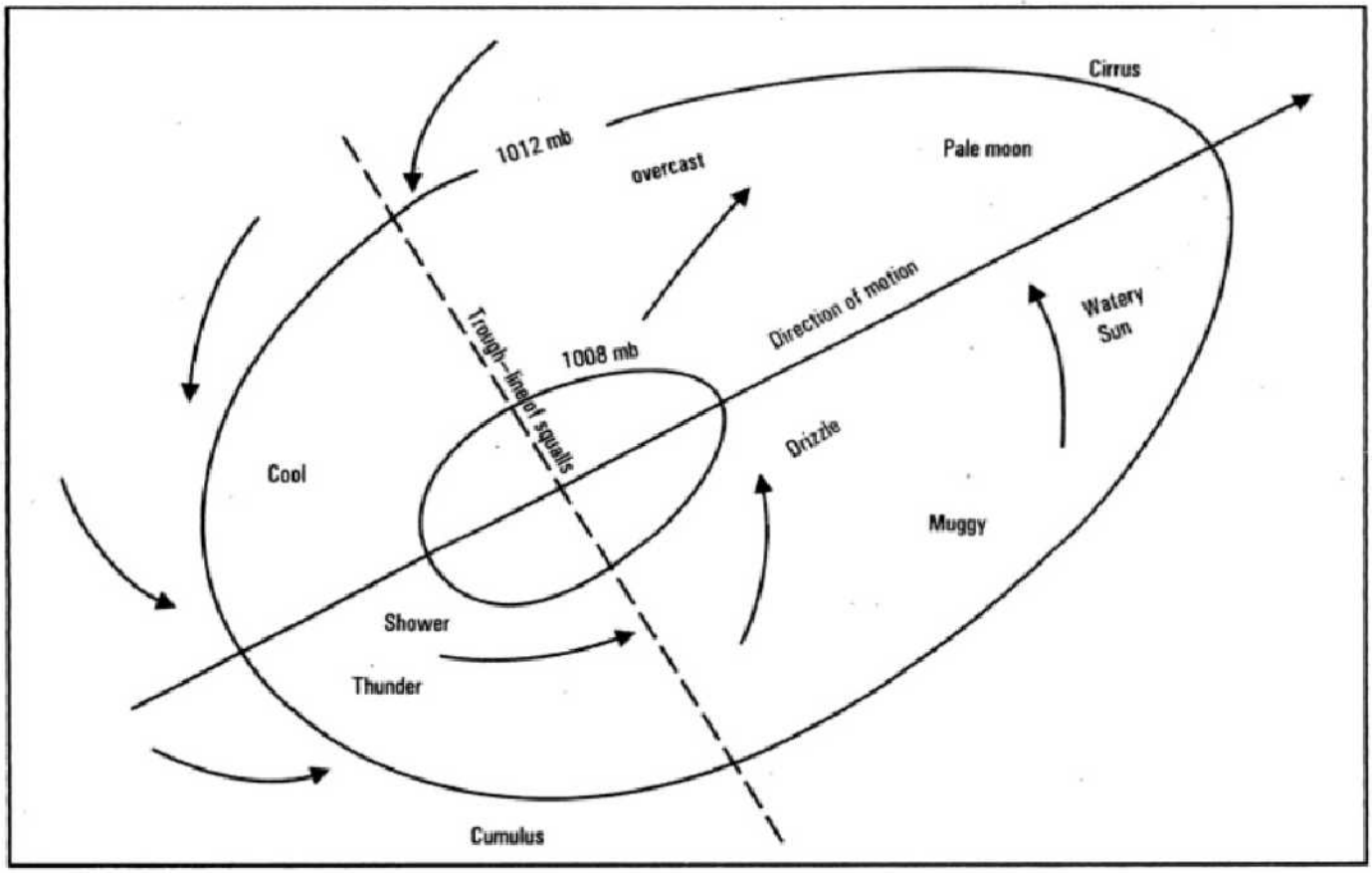

Fig. 3.28 – Weather in temperate cyclone

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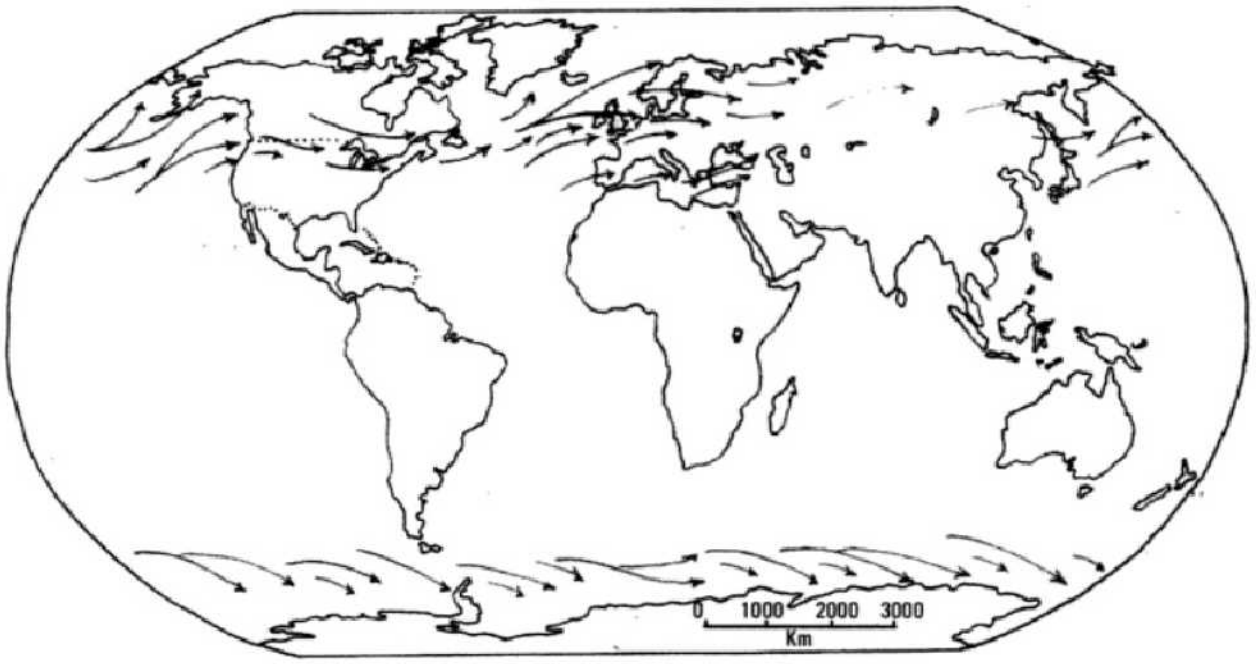

Fig. 3.29 – Principal paths of temperate cyclones

Sky is again covered with clouds which soon results into precipitation. The cold front sector precipitation is in the form of heavy downpour with cloud thunder and lightning, but the precipitation is of short duration and less widespread. The thunder and lightning are the indication of end of the cyclone and arrival of an anticyclone (blue sky).

Geographical Distribution of Temperate Cyclones

The major areas and tracks of temperate cyclones have been shown in **Fig. 3.29**. In general, the temperate cyclones occur in the higher mid-latitudes. In the Southern Hemisphere, there is a sharp peak in the frequency between 50° and 60° S. In the Southern Hemisphere they blow with more regularity, and there is little difference between summer winter tracks. In the Northern Hemisphere, there is a strong maximum in the frequency of temperate cyclone at 60°N in summer and 50°N in winter. This seasonal shift of about 10 degrees latitudes is due to the seasonal shift in the pressure belts.

In the Southern Hemisphere, the belt of maximum frequency of cyclones is almost contiguous around the world. Contrary to this, in the Northern Hemisphere, the zonal arrangement is much disturbed mainly due to the influence of continents and oceans **(Fig. 3.29)**.

Tropical Cyclones

It is a circular storm (or vortex) that rotates counter clock-wise in the Northern Hemisphere, and clockwise in the Southern Hemisphere. It is a powerful manifestation of energy and moisture systems in the eastern parts of continents in the tropical latitudes. These cyclones originate entirely within tropical air-masses, especially in the western parts of the oceans where the surface temperature varies between 25° and 27°C **(Fig. 3.30)**. The tropics extend from the Tropic of Cancer at 23.5° N to the Tropic of Capricorn at 23.5°S. Approximately, 80 tropical cyclones occur annually world-wide.

Origin of Tropical Cyclone

The origin of the tropical cyclones is not well understood. The origin of the tropical cyclones is, however, quite different from that of the temperate cyclones. The air of the tropics is essentially homogeneous, with no fronts or conflicting (warm and cold) air masses. In addition, the warm air and warm seas ensure an abundant supply of water vapour and thus the necessary latent heat to fuel these storms.

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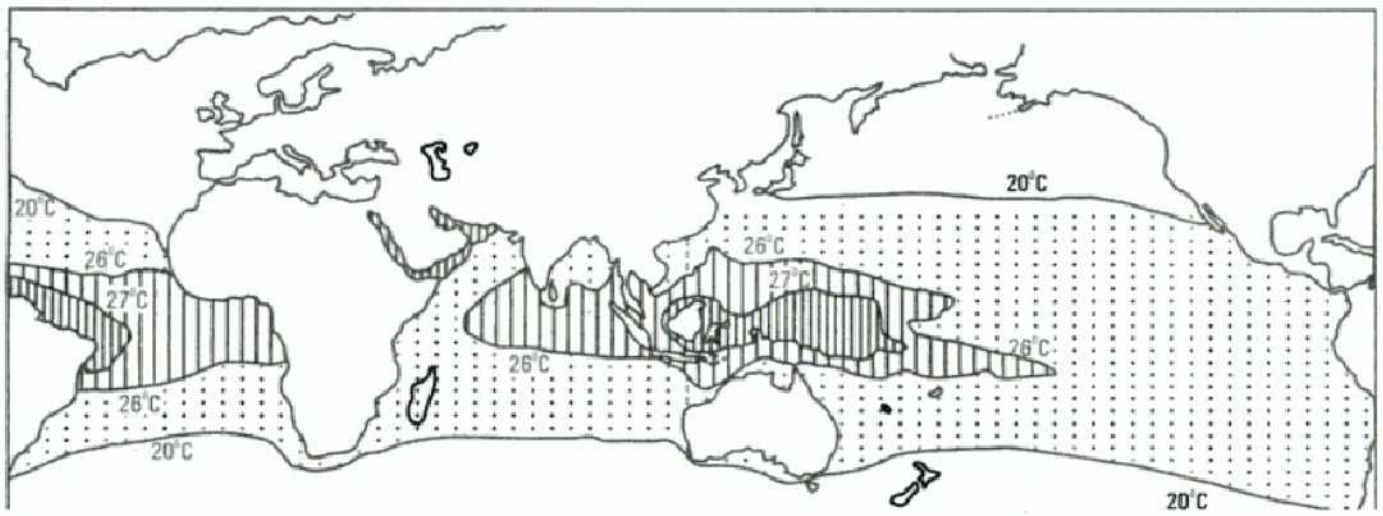

Fig. 3.30 – Average annual temperature. The western Pacific and western Atlantic Oceans record high temperatures in all seasons. (After R. W. Christopherson, Geosystems, 1995, p. 92)

Thus, these cyclones form within one warm, humid air mass between 10° and 25° in both the Hemispheres.

A tropical cyclone usually develops from a small tropical depression. Tropical depressions form in easterly waves, areas of lower pressure within the easterly trade winds. When air containing the disturbance is heated by the proximity of tropical water with a temperature of about 26°C or more, circular winds begin, and some of the warm humid air is forced upward. The coriolis effect also helps in the origin of tropical cyclones **(Fig. 3.31)**. Condensation begins in the ascending air and the tropical cyclone takes shape.

The centre of the most tropical cyclones move westward and poleward at a speed 10 to 40 km per hour. The typical tracks of some of the tropical cyclones are shown in **Fig. 3.32** In brief, in tropical cyclones, the condensation energy generates air movement (wind).

Characteristics of Tropical Cyclone

The main characteristics of tropical cyclones are given below:

1. The isobars are circular in shape.
2. Their diameter varies between 150 and 300 metres.
3. The central area is designated as the 'Eye' of the cyclone.
4. They do not have fronts (cold front and warm front).
5. They drive their energy from the latent heat.
6. Their velocity varies between 50 and 300 km per hour.
7. They occur in the autumn season.
8. The clouds in the tropical cyclone are cumulonimbus having vertical extension up to about 12 km.
9. They give torrential rainfall.
10. They are destructive causing great damage to life and property.

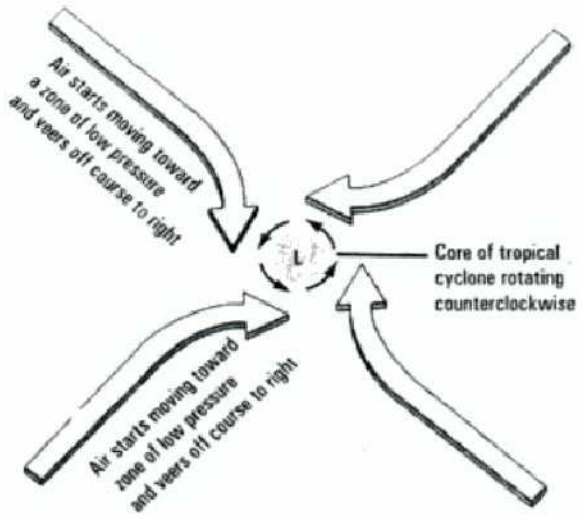
Air starts moving toward a zone of low pressure and veers off course to right
L
Core of tropical cyclone rotating counterclockwise
Air starts moving toward zone of low pressure and veers off course to right

Fig. 3.31 – The dynamics of a tropical cyclone, showing the influence of the Coriolis effect. Note that the storm turns the "wrong" way (that is, counterclockwise) in the Northern Hemisphere for the "right" reasons

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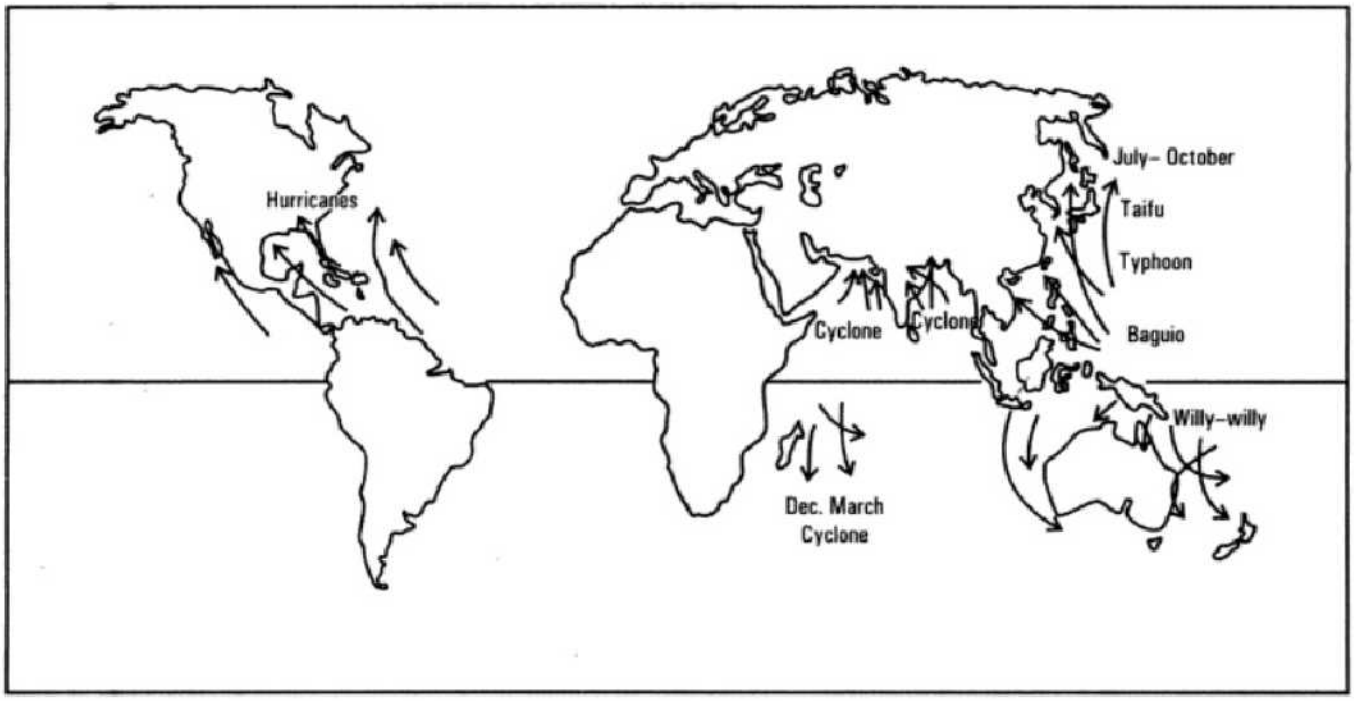

Fig. 3.32 – Areas of tropical cyclone

The tropical cyclones are known by different names in different parts of the tropical oceans:
China=Typhoons (Taifung)
Japan= Taifu
Philippines = Baigio
Carribean Sea = Hurricanes
Australia = Willi-Willis
Indian Ocean= Cyclone

Structure of a Tropical Cyclone

The inner most part of the tropical cyclone is known as the '*Eye*' of the cyclone **(Fig. 3.33)**. Its diameter ranges from 20 to 50 km. In the central part (Eye) of the tropical cyclone, the winds are light and variable; the clouds are either absent or scattered; the temperature is high; and the weather is sultry. In this central calm area, the sky is blue and there is intermittent sunlight against the background of spiral clouds about 12 km high.

In **Fig. 3.33**, the cloud bands can be seen as dark-shaded elongated patches spiraling away from the region of the cyclone. The central part of the tropical cyclone is surrounded by walls of cumulonimbus clouds. The maximum wind velocities are always recorded adjacent to the centre of the tropical cyclone. Moreover, the heaviest rainfall is recorded in the vicinity of this region. The winds slow down at uniform rate from the eye wall to the centre where rain practically ceases.

The tropical cyclone can cause loss of life and property damage. The destructive force of winds to 400 km per hour is self-evident. Torrential rainfall can cause severe flooding when the storm moves onto land. But the most danger lies in storm surge, a mass of water driven by the storm known as transgression of sea. Occasionally, there may be sea-waves up to 12 m in height.

In general, the tropical cyclones are destructive in nature. In Bangladesh, on 13th November, a tropical cyclone with wind speeds of more than 200 km per hour roared up the mouths of the Padma river, carrying with it masses of seawater up to 12 meters high. Water and wind clawed at the aggregation of small islands, most just above sea level, that makes up this impoverish country. In only 20 minutes at least 300,000 lives were lost, and estimates ranged 1 million dead alongwith huge property damage. Photographs taken soon after the storm showed a horizon-to-horizon morass of flooded, deep-gashed ground tortured by

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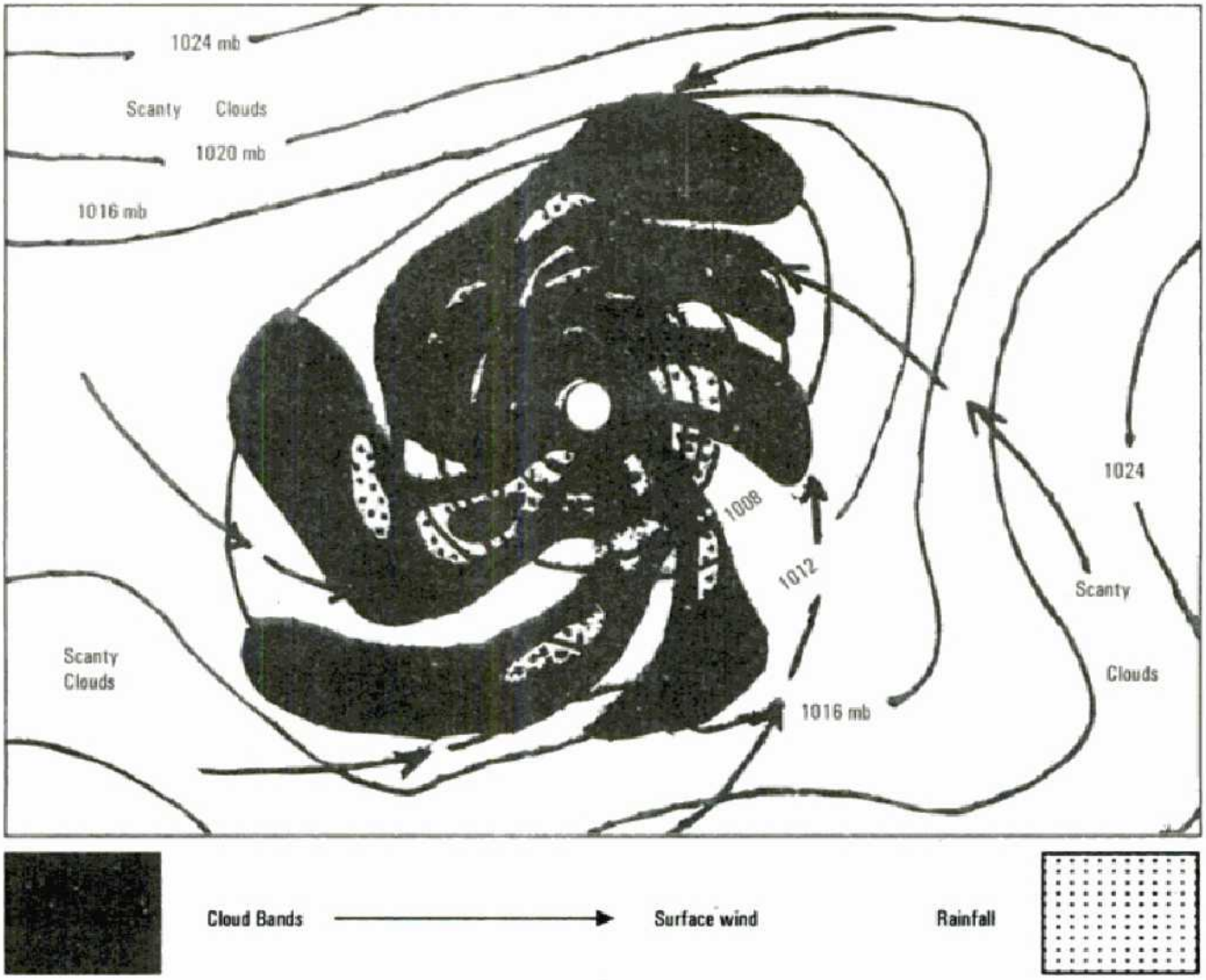

Fig. 3.33 – Cross section of a tropical cyclone

furious winds. There was almost no trace of human inhabitants, farms, domestic animals, or villages. Another great storm, which struck in May 1991, killed another 200,000 people. The economy of the shattered country may never fully recover. The tropical cyclones are dangerous examples of power represented by water's latent heat of fusion.

Tornado

It is an intense, destructive cyclonic rotation, developed in response to extremely low-pressure and associated with mesocyclonic formation. It is a converging spiral of air with wind speeds estimated at several hundred kilometers per hour. It is most violent of atmospheric storms, but it is seldom larger than a kilometer in diameter. The direction of rotation is counterclockwise in the Northern Hemisphere except in rare instance **(Fig. 3.34).** The tornado depends on moisture as an energy supply and occurs mostly in moist tropical air. Funnel clouds form out of other clouds. They work downward toward the ground. The funnel cloud of condensed moisture hanging from the storm cloud makes the tornado readily visible. The cloud may vary widely in thickness and sometimes may be larger at the bottom than at the top. Most often it is gray in colour due to condensed water vapour. In winter, a tornado may touch down on a field of snow and become a brilliant white.

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Origin Of Tornados

Tornados occur most often with thunderstorm activity. Ideal Conditions for tornado formation are those found ahead of cold front. Tornados from the collision of mass of warm, very moist air with cooler, drier air from polar regions. For tornadoes to form, several prerequisites are essential, which are given below:

1. There must be a mass of very warm, moist air present at the surface.

2. There must be an unstable vertical temperature structure.

3.There must be a mechanism present to start rotation.

Tornado Forecasting

The main factor in the high death rate is the problem of prediction and detection. Tornadoes are so localised in extent and random in distribution that it is very difficult to forecast them.

Anticyclone

It is an area of above average atmospheric pressure characterised by a generally outward flow of air at the surface. The direction of wind is clockwise in the Northern Hemisphere and anticlockwise in the Southern Hemisphere (Fig. 3.35).

The term anticyclone was used for the first time by *F. Galton in 1861*. It is a dynamically or thermally caused area of high atmospheric pressure with descending and diverging air flow. The salient characteristics of an anticyclone are as under:

(i) The isobars of an anticyclone are generally circular in shape (Fig. 3.35).

(ii) They are much larger in size than that of the temperate cyclones.

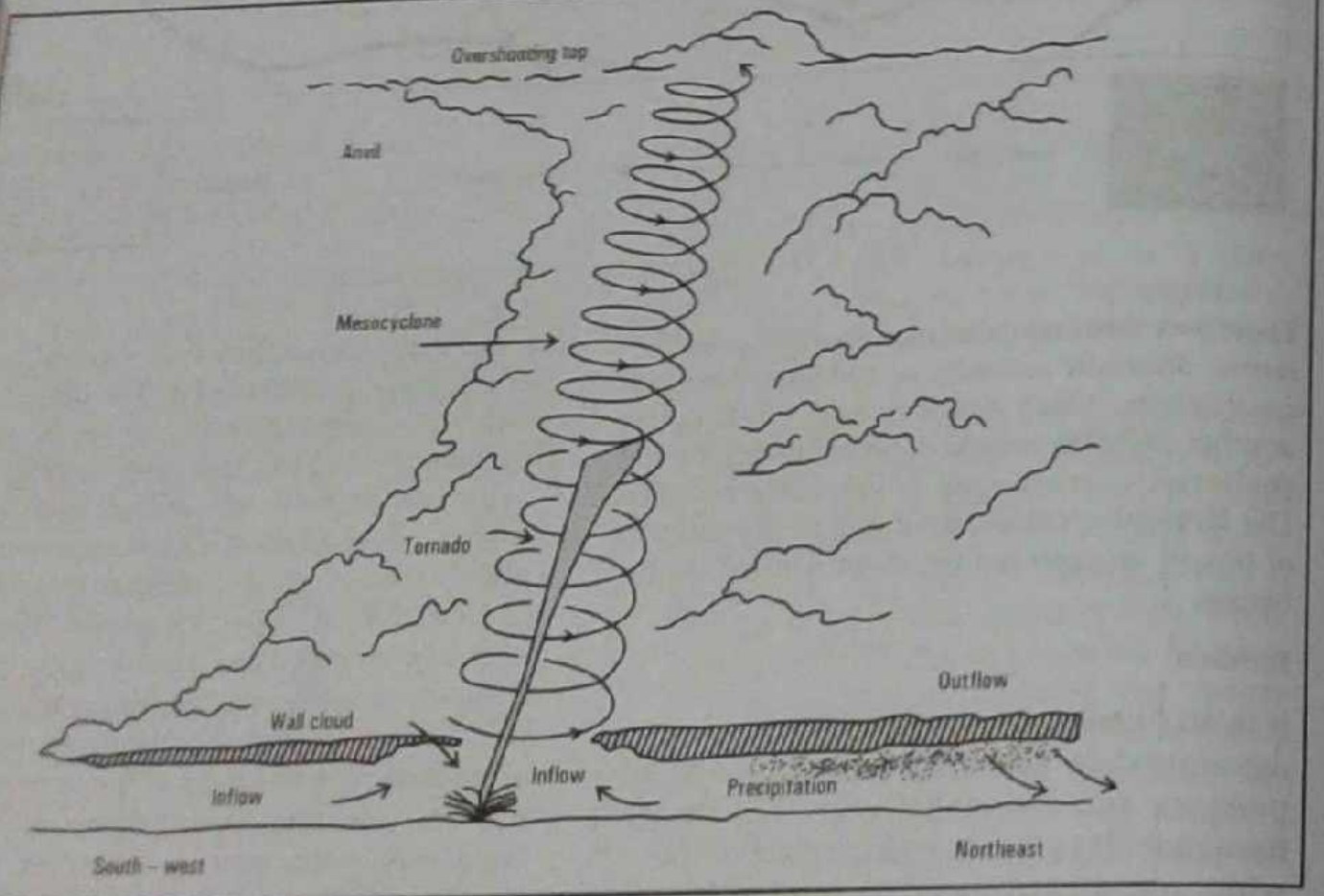

Fig. 3.34 – Development of a mesocyclone and tornado (After Donald Ahrens C., Meteorology, West Publishing Co.1988)

(iii) Their track is highly variable and unpredictable.
(iv) The high pressure lies in the centre.
(v) The wind blows outward from the centre. The direction of wind is clockwise in the Northern Hemisphere and anticlockwise in the Southern Hemisphere.
(vi) Temperature in an anticyclone depends on the prevailing weather, humidity and the nature of the air-mass.
(vii) Anticyclones do not have fronts.
(viii) Anticyclones are the indicators of blue sky, clear weather and no rainfall.

Types of Anticyclones

Anticyclones may be classified into:

(a) Cold anticyclones

The cold anticyclones generally originate in the Arctic and Antarctic regions and advance in the easterly and south-easterly direction. They are of very low thickness. These anticyclones die out when entering in the tropical regions.

(b) Warm anticyclones

The warm anticyclones originate in the belt of subtropical high pressure where the winds descend in the Hadley's cell. These are associated with light wind, low humidity and cloudless skies.

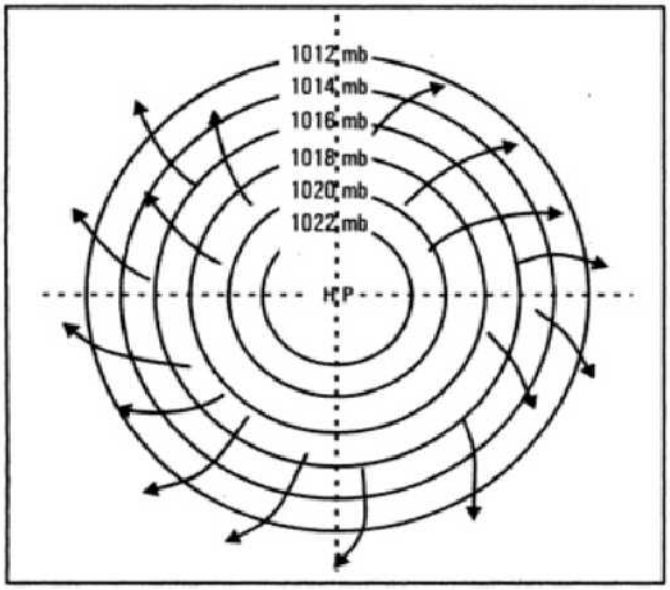

Fig. 3.35 – Anticyclone-air pressure and wind system in the Northern Hemisphere

(c) Blocking anticyclones

The blocking anticyclones develop due to obstruction in the air circulation in the upper atmosphere. This is why they are called as blocking anticyclones. They develop over North-West Europe and the Pacific Ocean between 140-170 W longitudes. They are similar to warm anticyclones as the wind system is concerned, but they move very slowly.

Jet Stream

Jet stream is a strong wind blowing from west to east in the upper part of the troposphere, usually near the level of tropopause (about 12,000 m above the sea level) in sinuous band. The jet streams are normally 160-480 km wide by 900-2150 m thick with a core speed that can exceed 300 kmph. Normally, the speed of a jet stream varies from a mean of 110 km per hour in summer to about 190 kmph in winter. In exceptional cases a speed of 375 kmph has also been recorded. The main types of jet streams are: (i) the sub-tropical jet stream, (ii) the polar front jet stream of the middle latitudes, and (iii) the Arctic/Antarctic Jet streams. The sinuous movement of jet stream has been shown in **Fig. 3.36.**

The global patterns of temperature, pressure, horizontal and vertical circulation of the atmosphere, the behaviour of monsoon, the intensity of precipitation, the weather and climates are largely influenced by the position, thickness, dimensions and movements of the jet streams.

Moisture in the Atmosphere

Hydrological Cycle

A hydrological cycle is a conceptual model of the exchange of water over the Earth's surface. A model of hydrological cycle has been shown in **Fig. 3.37** It shows the large scale changes in

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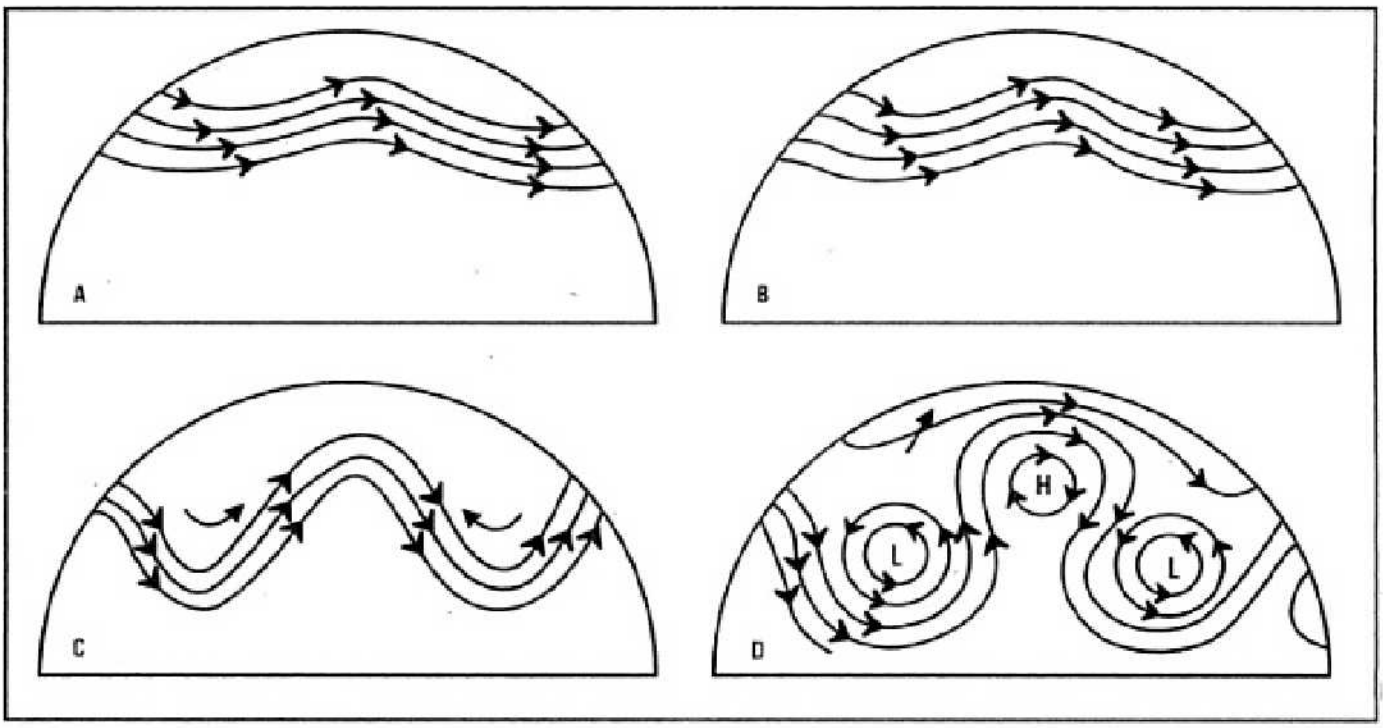

Fig. 3. 36 – Jet stream cycle

the state of water, passing through the processes of evaporation, condensation and precipitation. Transpiration is, in some ways, a special form of evaporation in which moisture returns to air through evaporation via vegetative processes. The evaporation from the vegetation is known as evapotranspiration.

Some of the moisture of the precipitation that falls to surface passes to the soil to become soil moisture, some passes deeper into the ground to become ground water. Other precipitation runs off the surface and is collected in ponds, lakes or flows as surface water in streams and rivers. Eventually, water finds its way to the oceans and starts the cycle over again.

The proportional distribution of water over the Earth's surface has been shown in **Fig. 3.38.** It may be seen from **Fig. 3.38** that 97 per cent of the Earth's water is in the oceans. The remaining 3 per cent is mostly ice found in the large ice-caps of the world (Antarctica and Greenland). Almost all of the rest is ground water. Rivers, lakes, and soil moisture account for less than one per cent of the total water. The atmosphere contains only 0.35 per cent of all water available. Yet this small amount provides the moisture for clouds and precipitation that occurs over the Earth's surface.

Humidity

Humidity is the amount of water vapour in the air, affecting the level of comfort and chance that cloud will form.

Relative Humidity

This is a widely used measure of water vapour in the atmosphere. The calculation of relative humidity depends on the maximum amount of moisture that air can hold – the saturation level. The relative humidity of an air sample is expressed as a percentage which is found by relating the observed vapour pressure at a given temperature to the saturation value of vapour pressure at that temperature. The formula for relative humidity is:

Relative humidity commonly displays a daily cycle which has phase opposite to that of temperature so that the highest values are observed near dawn and the lowest during the

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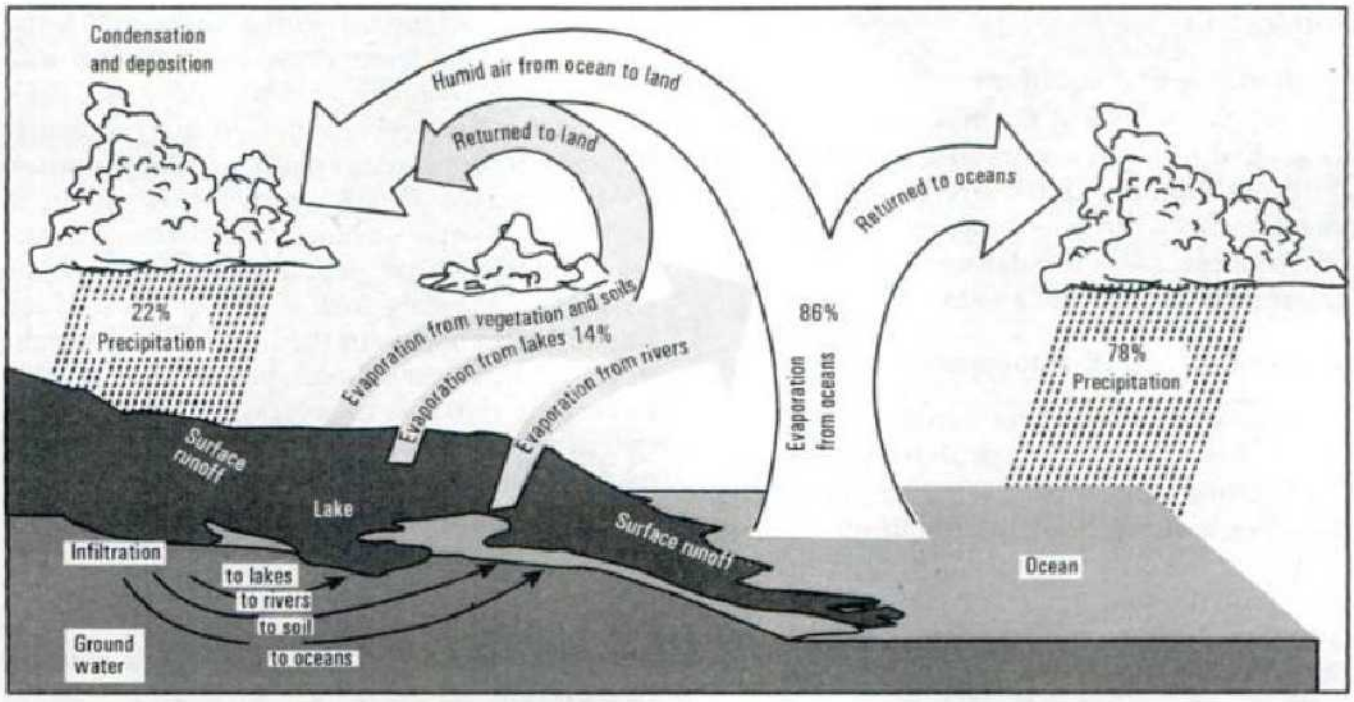

Fig. 3.37 – Hydrological cycle (after A. Strahler, 1997)

$$\text{Relative Humidity} = \frac{\text{Actual water vapour content of the air}}{\text{Maximum water vapour capacity of the air}} \times 100$$

afternoon. Air is said to be saturated, or full, if it is holding all the water vapour that can be hold at a given temperature (100% relative humidity). Saturation indicates that any further addition of water vapour (increase in content) or any decrease in temperature (reduction in capacity) will result in active condensation, fog or precipitation.

Specific Humidity

The mass of water vapour (in grams) per unit mass of air (in kilograms) at any specific temperature.

Absolute Humidity

The density of the water vapour present in a mixture of air and water vapour, that is the ratio of the mass of water vapour to the volume occupied by the mixture, usually measured in grams per cubic centimeter. Cold air cannot contain as much water vapour as warm air, so cold air has a lower absolute humidity than warm air.

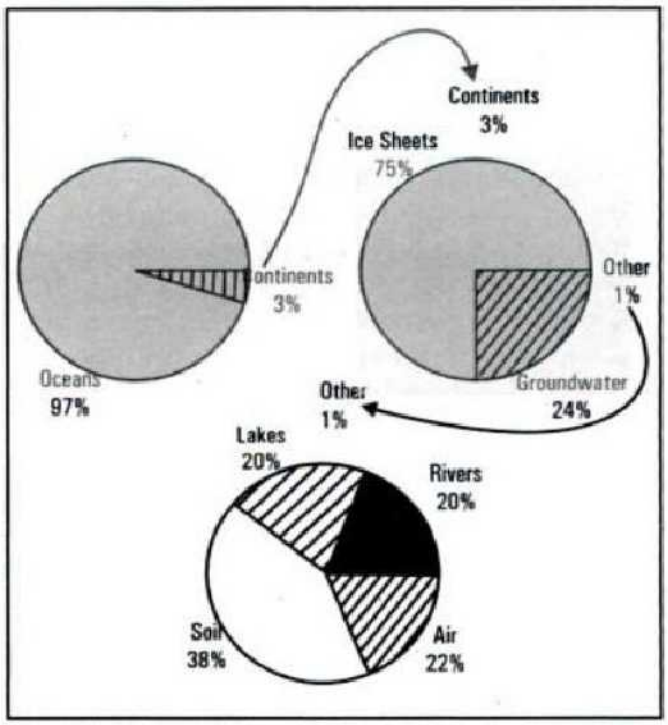

Fig. 3.38 – The proportional distribution of water over the Earth's surface (after John E. Oliver, et. al, 2002, Climatology, p. 62)

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Evaporation

The changing of a liquid into a vapour, or gas, at a temperature below the boiling point of that liquid. Evaporation occurs at the surface of a liquid, and energy is required to release the molecules from the liquid into the gas. The use of this energy, known as latent heat, causes the temperature of the liquid to fall.

Transpiration or (Evapotranspiration)

The release of water vapour from the Earth is surface by evaporation and transpiration. Transpiration is the biological process whereby plants lose water vapour, mainly through pores in their leaves. This water is usually replaced by a continuous flow of water moving upwards from the roots. Rates of evapotranspiration vary with factors such as the temperature and humidity of the air, wind speed, plant type and the nature of the land surface. Since evapotranspiration is so variable, physical geographers prefer to use the concept of potential evapotranspiration (PE). This is the greatest amount of water vapour which could be diffused into the atmosphere given unlimited supplies of water.

Condensation

The change of a vapour or gas into liquid form is known as condensation. Condensation in meteorology can be caused by: the cooling of constant volume of air to dew point, the expansion of a parcel of air without heat input, the evaporation of extra moisture into the air, the fall in moisture-holding capacity of the air due to changes in both volume and temperature, and contact with a colder material or air mass. Condensation may be of the following types:

Precipitation

In meteorology, precipitation is the deposition of moisture from the atmosphere onto the Earth's surface. This may be in the form of rain, hail, frost, fog, sleet, or snow. Precipitation develops in two stages. Initially, cloud droplets grow around nuclei through condensation and diffusion. In clouds, warmer than -10°C, the larger droplets then grow by collision and coalescence with the similar ones. In colder clouds the Bergeron-Findeisen mechanism is thought to operate, probably in conjunction with the growth of ice crystals through accretion, as super-cooled water droplets freeze on impact with the ice, and aggregation, as smaller ice crystals stick to larger ones. Much precipitation begins in the form of ice crystals, develops into snow flakes, but melts as it falls, to become rain. On an average 10 inches (25.4 cm) of snow equals to about 1 inch (2.5 cm) of rain, though the actual ratio varies. Dry, powdery snow equals less than wet, heavy snow.

Dew

The direct deposition of water vapour without hygroscopic nuclei on the surfaces of objects on the ground like vegetation is known as dew. Dew occurs, when there is high relative humidity, calm air, high rate of radiation, clear skies. Dew is, however, shortlived as it disappears after the rising of Sun.

Fog

Fog is a cloud layer on the ground, with visibility restricted to less than one kilometer. The presence of fog is an indication that the air temperature and the dew point temperature are nearly identical, producing saturated conditions. Fog generally occurs when there is inversion of temperature. Fog may be classified into:

(i) Advection fog

Active condensations formed when moist air moves laterally over cooler water of land surfaces, causing lower layers of the overlying air to be chilled to the dew temperature.

(ii) Radiation fog

It is formed by a radiative cooling of the surface, especially on clear nights of calm atmosphere in areas of moist grounds; occurs when the air layer directly above the surface is chilled to the dew-point temperature, thereby producing saturated conditions.

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Foggy Regions of the World

The occurrence of fog is confined to some favourable regions of the world. The areas in which the frequency of fog is high are shown in **Fig. 3.39.** The regions of New-Foundland, California, Chile Coast, Coast of Namibia, the Western Coast of Australia, the Sea of Okhotsk and Bering Sea record fog almost throughout the year. The interior parts of Europe, North America, Eastern Australia, Central China, and Northern India record the radiation fog during the winter season.

Frost

It is the frozen dew or fog forming at, or near ground level. Air below 0°C is air-frost. Hoar frost, or rime, is a thick coating of white ice crystals on vegetation and other surfaces. Ground frost occurs when the air at ground level is chilled below freezing point. Its frequency is high in the mid-latitudes and mountainous areas during the winter season.

Mist

A suspension of water droplets in the air which restricts visibility to between 1 and 2 km.

Rain

Rain is a form of precipitation consisting of water droplets ranging from 1 to 5 mm in diameter.

Drizzle

Rain made of very small droplets, up to 0.2 mm across, and with a fall speed of around 0.8 m^{s-1}. Dense drizzle is not to be confused with light rain, which has at least 3 mm droplets.

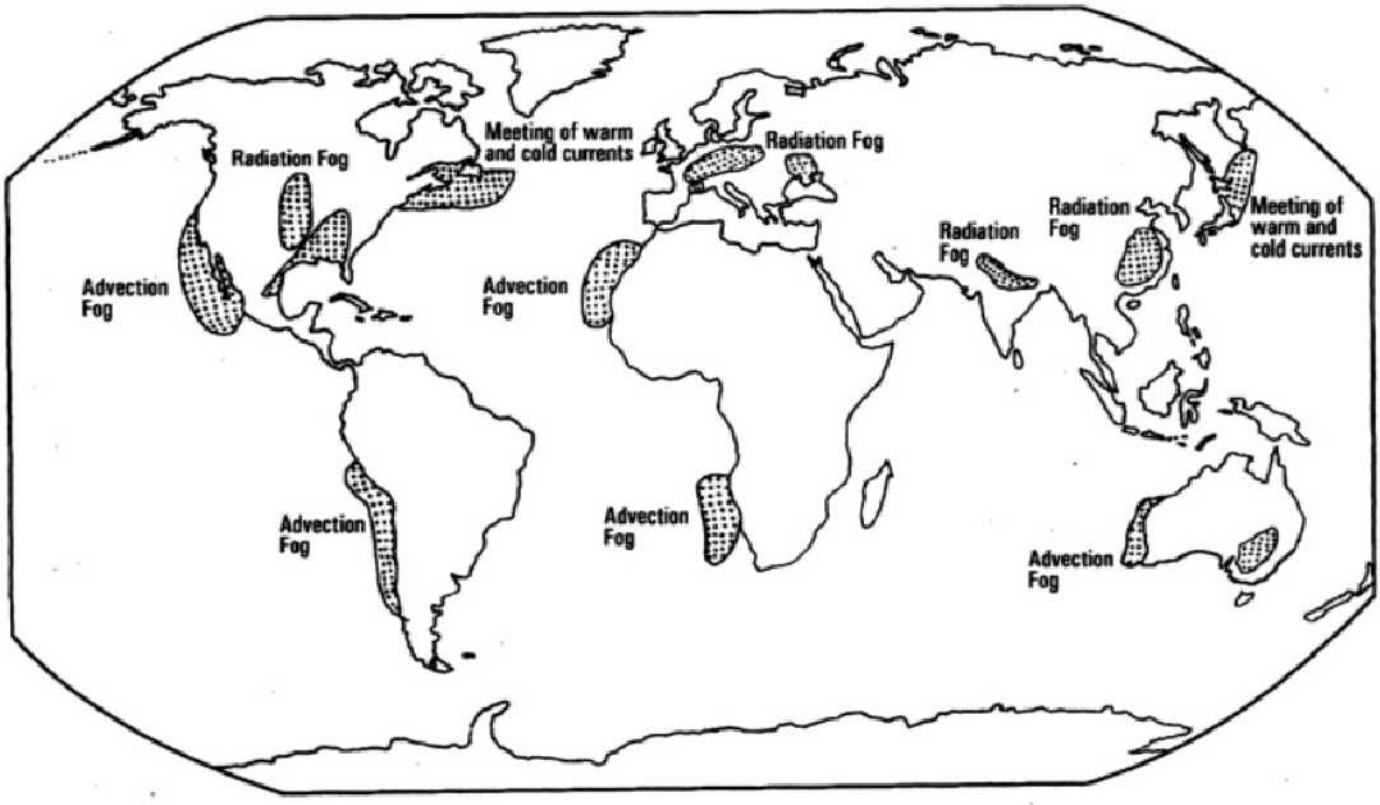

Fig. 3.39 – Main areas affected by fog

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Freezing Rain or Freezing Drizzle

This is a rain/drizzle that freezes on impact with the ground, with objects on the Earth's surface, or with aircraft in flight.

Rime

It is an opaque coating of tiny, white, granular ice-particles, caused by rapid freezing of super-cooled water droplets on impact with objects.

Hail

Hail is the precipitation of small balls or pieces of ice (hailstones), with diameters ranging from 5 to 50 mm, falling either separately or agglomerated into irregular lumps. Hailstones are comprised of a series of alternating layers of transparent and translucent ice. They form when a frozen raindrop is caught in the violent updraughts found in warm, wet cumulonimbus clouds. As they rise, they attract ice, and as they fall, the outer layer melts, but refreezes when the droplet is again lifted by updraughs. Onion-like structure of hailstone shows that they must have passed up and down several times. A hailstone will descend when its fall-speed is enough to overcome the updraughts in the cloud.

Hail Snow

Snow is a precipitation of ice crystals most of which are branched. At temperatures higher than about -5°C, the crystals are generally agglomerated into soft-flakes.

Snow Pellets

Snow pellets are composed of white and opaque grains of ice. The grains are mostly spherical and have a diameter of 2-5 mm. The grains are brittle when falling on a hard surface bounce and break up. Snow pellets are also known as soft hail or graupel.

Snow grains

Snow-grains are very small grains of white, opaque ice. Snow grains are also called graupel.

Ice pellets

These are comprised of transparent or translucent pieces of ice that are spherical or irregular. They are composed of frozen raindrops or largely melted and refrozen snowflakes.

Ice-prism (diamond-dust) : Ice prisms are ice-crystals often tiny that they seem suspended in air. Such crystals may fall from a cloudy or cloudless sky. Mostly visible when they glitter in sunshine (hence diamond dust), they occur at very low temperatures.

Fog, ice-fog and mist : Fog, ice-fog and mist are also considered forms of precipitation.

Clouds Forms and Classification

Cloud is a visible, dense mass of suspended water droplets and or ice crystals suspended in the air. Clouds are generally formed when air is forced to rise at a front, over mountains, or because of convection.

Types of Clouds

The first classification of clouds was given by **Luke Howard (Englishman) in 1803.** He distinguished three principal cloud forms:

1. Stratus (from Latin stratum=layer) cloud – lying in a level sheet.
2. Cumulus (from Latin cumulus = pile) cloud–having flat bases and rounded tops, and being lumpy in appearance.
3. Cirrus (from Latin=hair) cloud – having a fibrous or feathery appearance. This system was revised several times. The international standard is now under the auspices of the World Meteorological Organization (WMO), which published *The International Cloud Atlas.*

There are ten basic types of clouds as given in *The International Cloud Atlas* **(Fig. 3.40).** The principal types of clouds are as under:

High Clouds (above 7000 metres)

1. Cirrus (Ci)

Detached clouds in the form of white, delicate filaments, or white or mostly white patches or narrow bands. These clouds have a fibrous (hair-like) appearance or a silky sheen or both **(Fig. 3.40).**

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2. Cirrocumulus (Cc)

These are thin, white patch, sheet, or layer of clouds without shading composed of very small elements in the form of grains, etc., merged or separate, and more or less regularly arranged; most of the elements have an apparent width or less than 1° – approximately the width of the little finger at arms length **(Fig. 3.40).**

3. Cirrostratus (Cs)

Transparent, whitish cloud veil of fibrous or smooth appearance, totally or partially covering the sky or mackerel sky, and generally producing *halo* phenomena.

Middle Clouds (2000 to 7000 metres)

4. Atocumulus (Ac)

White or gray, or both white and gray, patch, sheet, or layer of cloud, generally with shading, composed of rounded masses, rolls, etc., sometimes partly fibrous or diffuse, and may or may not be merged; most of the regularly arranged small elements usually have an apparent width of between 1°and 5° – approximately the width of three fingers at arms length **(Fig. 3.40).**

5. Altostratus (As)

Grayish or bluish cloud sheet or layer of striated, fibrous, or uniform appearance, totally or partly covering the sky, and having parts thin enough to reveal the Sun at least vaguely, as through ground glass. The Sun is dimly visible, the altostratus clouds, however, do not show *halo* phenomena.

Low Clouds (Below 2000 m)

6. Nimbostratus (Ns)

Gray cloud layer, often dark, the appearance of which is rendered diffuse by more or less continually falling rain or snow, which, in most cases reaches the ground. It is thick enough throughout to bolt out the Sun. Low ragged clouds frequently occur below the layer with which they may or may not merge **(Fig. 3.40).**

7. Stratocumulus (Sc)

Gray or whitish, or both gray and whitish, patch- sheet or layer of cloud that almost always has dark parts, composed of tessellations, rounded masses, rolls, etc., that are non-fibrous (except for *virga*) and may or may not be merged **(Fig. 3.40).**

8. Stratus (St)

Generally gray cloud layer with a fairly uniform base, which may give drizzle, ice prisms, or snow grains. When the Sun is visible through the cloud, its outline is clearly discernible. Stratus does not produce halo phenomena (except possibly at very low temperatures). Sometimes stratus appears in the form of ragged patches **(Fig. 3.40).**

9. Cumulus

Detached clouds, generally dense and with sharp outlines, developing vertically in the form of rising mounds, domes, or towers, of which the bulging upper part often resembles a cauliflower. The sunlit part of these clouds are mostly brilliant white; their bases are relatively dark and nearly horizontal. Sometimes cumulus is ragged **(Fig. 3.40).**

10. Cumulonimbus (Cb)

Heavy and dense clouds, with considerable vertical extent, in the form of a mountain huge towers. At least part of its upper portion is usually smooth, or fibrous of striated, and nearly always flattened; this part often spreads out in the shape of an anvil or plume. Under the base of this cloud, which is often very dark, there frequently low ragged clouds either merged with it or not. The cumulonimbus clouds give torrential rainfall. Lightning and thunder are also the common features of these clouds **(Fig. 3.40).**

Lightning and Thunder

An estimated 8 million lightning strikes occur each day on the Earth. Lightning refers to flashes of light caused by enormous electrical discharges – tens to hundreds of millions of volts – which briefly superheat the air to temperatures of 15,000° to 30,000°C. The violent expansion of this abruptly heated air sends shock waves through the atmosphere – the sonic bangs known as thunder. The greater

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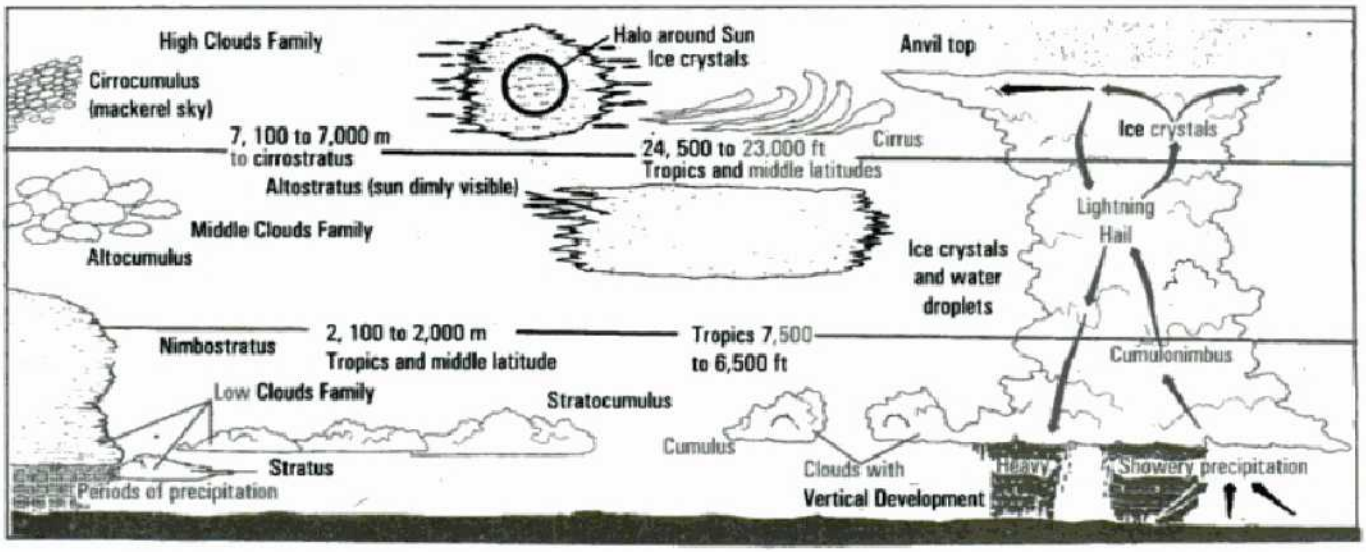

Fig. 3.40 – Cloud types

the distance a lightning stroke travels, the longer the thunder echoes. Lightning at great distance from the observer may not be accompanied by thunder and is called *heat-lightning*. Lightning poses a hazard to aircraft and to people, animals, trees, and structures. At the time of lightning people should remain indoor.

Types of Rainfall

The meteorologists generally classify rainfall into the following three categories:

(i) Convectional or Convective Rainfall: The rain which is caused by the process of convection in the atmosphere is known as convectional rainfall. When the surface layers of the atmosphere are heated, the moisture-laden air rises in a convection current. The moist heated air expands, its density falls, and it rises convectionally. It is thereby cooled adiabatically and its temperature falls below the dew point, thereby forming clouds. Such clouds are generally of cumulonimbus type, which generate heavy rainfall. This type of rainfall generally occurs throughout the year in the equatorial region, where high temperatures and high humidity produce convectional currents. Rainfall of this type is also associated with the cold front of an unstable polar air-mass, cloud burst and thunderstorms, especially in the monsoon regions **(Fig. 3.41-a)**.

(ii) Orographic Rainfall: This is also known as *relief rainfall*. It occurs when moisture-laden air masses are forced to rise over high ground (mountains). The air is cooled, the water vapour condenses, and rainfall occurs. Some experts maintain that relief merely intensifies the precipitation caused by convection or formed at fronts. The term *orographic intensification* is, therefore, used occasionally **(Fig. 3.41-b)**.

(iii) Cyclonic or Frontal Rainfall: Rain associated with the passage of cyclone or depression is known as cyclonic rainfall. It occurs mainly in temperate latitudes when a warm, moist air mass moves upwards over colder heavier air. A distinction can be made between the prolonged drizzling rain which falls from the *warm front* and the shorter by heavier bursts of rain associated with the passage of *cold front*. In Europe and North America, most of the winter rainfall is frontal in origin. Winter rainfall in the northern parts of India is also the result of cyclonic depressions **(Fig. 3.41-c)**.

Regional Distribution of Precipitation

The mean annual precipitation for the entire Earth is about 100 cm (approximately 40 inches). Precipitation data for the oceans is

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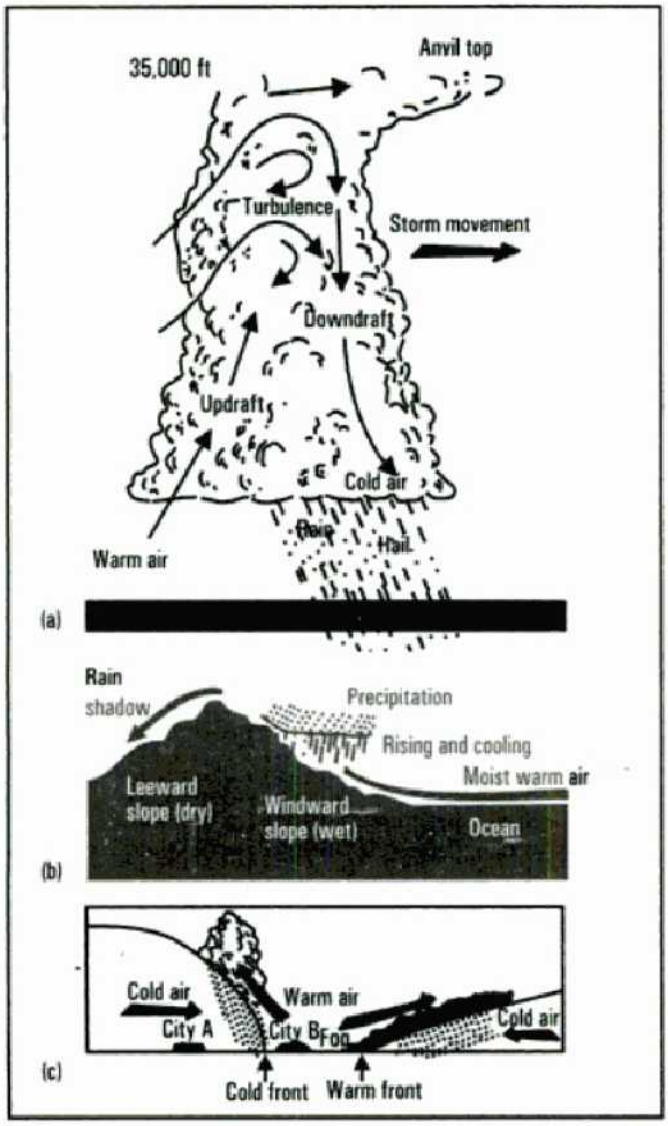

Fig. 3.41 – Three types of lifting mechanisms

extremely limited, and those for mountain ranges, forest areas, and wind swept coasts are largely estimates. The distribution of precipitation on the Earth is highly uneven. Several climatic factors like latitudes, temperature, pressure, relative humidity, air masses, differential heating and orographic features influence the distribution of rainfall.

The latitudinal distribution of rainfall has been shown in **Fig. 3.42**. It may be seen from this figure that the equatorial region records the highest average annual rainfall. The amount of rainfall decreases towards the poles. In the monsoon climate, the highest rainfall is recorded in the summer months being July to September in the Northern Hemisphere and January to March in the Southern Hemisphere. The average annual rainfall is low in the subtropical high pressure belt in which the air of the Hadley's Cell descends from above. All the hot deserts and semi-arid areas of the world are confined to this belt. The average annual rainfall in the subtropical high pressure belt is less than 25 cm. In the temperate region (belt of westerlies), the amount of rainfall varies between 100 and 125 cm which decreases from west to east. In the polar areas, characterised by cold air masses, the amount of average rainfall is less than 25 cm **(Fig. 3.43)**.

The distribution of land and water imposes an important control over the distribution rainfall. Regions located in the interior lands and the leeward sides of the mountains receive low rainfall as compared to the coastal and windward sides. In general the Southern Hemisphere (Water Hemisphere) records more rainfall than the Northern Hemisphere.

El-Nino

El Nino phenomenon occurs when the usual east-to-west equatorial current in the Pacific weakens or reverses, pushing warm waters to the west coast of South America. In an El-Nino year, there appears a warm water current along the coast of Peru which replaces the normally cold rising water. Fishermen of Spanish origin named this event as El-Nino. It implies *'the Little One'* after the Christ Child, as the event appears most often in late December. El-Nino has occurred frequently since first reported in 1541.

In some years, El-Nino becomes stronger and exceptionally warmer than usual. It produces rain over the coastal Atacama desert of Chile and Peru. The rain brings a period of profound vegetation growth. The desert provides abundant grazing for herds of sheep and goats.

In the lower latitudes of the Pacific, surface temperature of the ocean averages around 26° to 27°C. These surface temperature changes take place mostly within 8°C of the equator. In an El-Nino year the surface temperature increases more than 3°C. During El-Nino, the area of warm water expands eastward and the area of convergence and precipitation drifts

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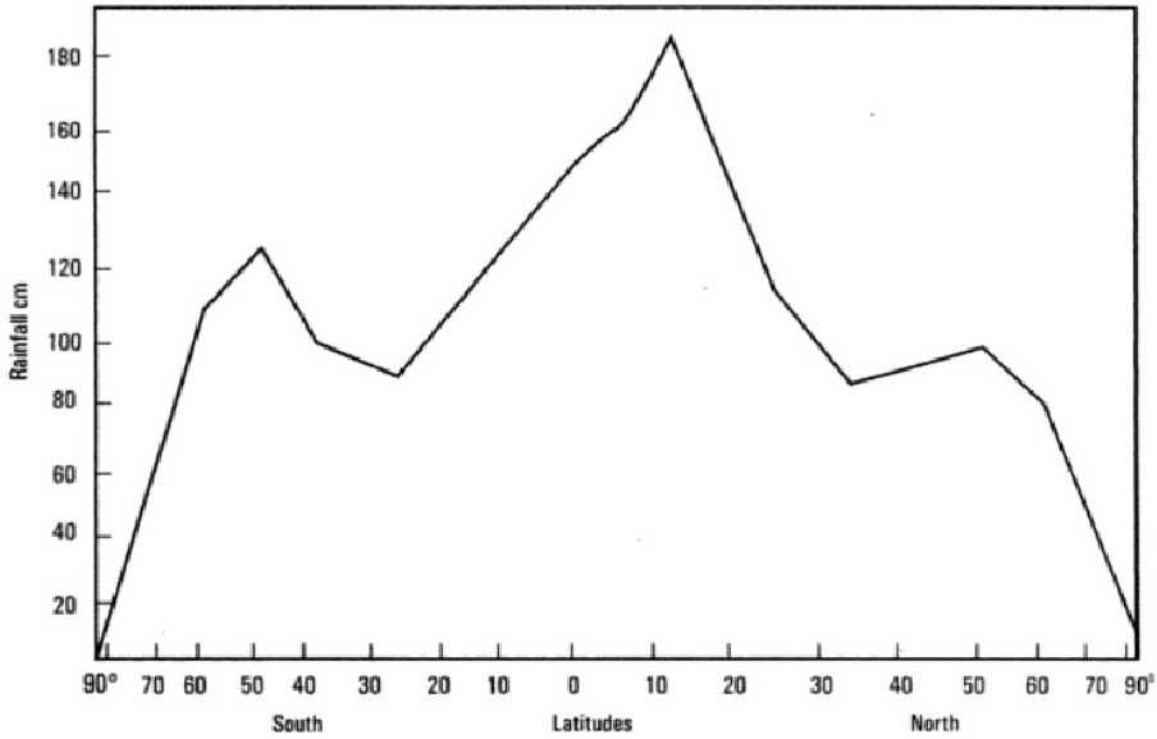

Fig. 3.42 – Latitudinal distribution of precipitation

eastward **(Figs. 3.44-45)**. Consequently, rainfall increases over the eastern Pacific Ocean along the west coast of South America. Pressure differences decrease and the trade winds die down. Pressure difference between Darwin (Australia) and the island of Tahiti shows the southern oscillation. During El-Nino, pressure increases at Darwin, consequently, rainfall decreases while, in opposition to this air pressure decreases at Tahiti and rainfall increases.

The consequences of 1982-1983 – the most severe El-Nino year recorded the following effects:

1. Monsoon failed in South Asia (India, Bangladesh, Sri-Lanka, Nepal, Bhutan and Myanmar), and South-East Asia (Indonesia, Vietnam, Thailand, Malaysia, China, etc.).
2. Drought in South East Asia, and the *Sahel* region of Africa.
3. Drought in Australia and New Zealand.
4. Heavy rains, floods, and landslides in Peru, Ecuador, Columbia and Chile (Andes Mt.).
5. Increased frequency of tropical cyclones in Tahiti.
6. Above normal temperatures in Alaska and North-Western Canada.
7. The warmest winters in USA in 25 years.
8. Floods in Cuba and Louisiana (USA).
9. Death of coral reefs in Pacific Ocean and in the Caribbean Sea.
10. Reduction of fish along the coast of Peru.
11. High mortality of seabirds in the islands of Pacific Ocean.
12. Increased cases of malaria. Outbreak of fevers in South and South -East Asian and Latin American countries.

Forecasting El-Nino

El-Nino occurs every few years like many cyclic phenomena. The frequency appears to be on the increase. Since they have been documented, they have averaged one after every seven years. There is great difficulty in the El-Nino forecasting as it does not have a fixed interval. Each event begins and develops differently.

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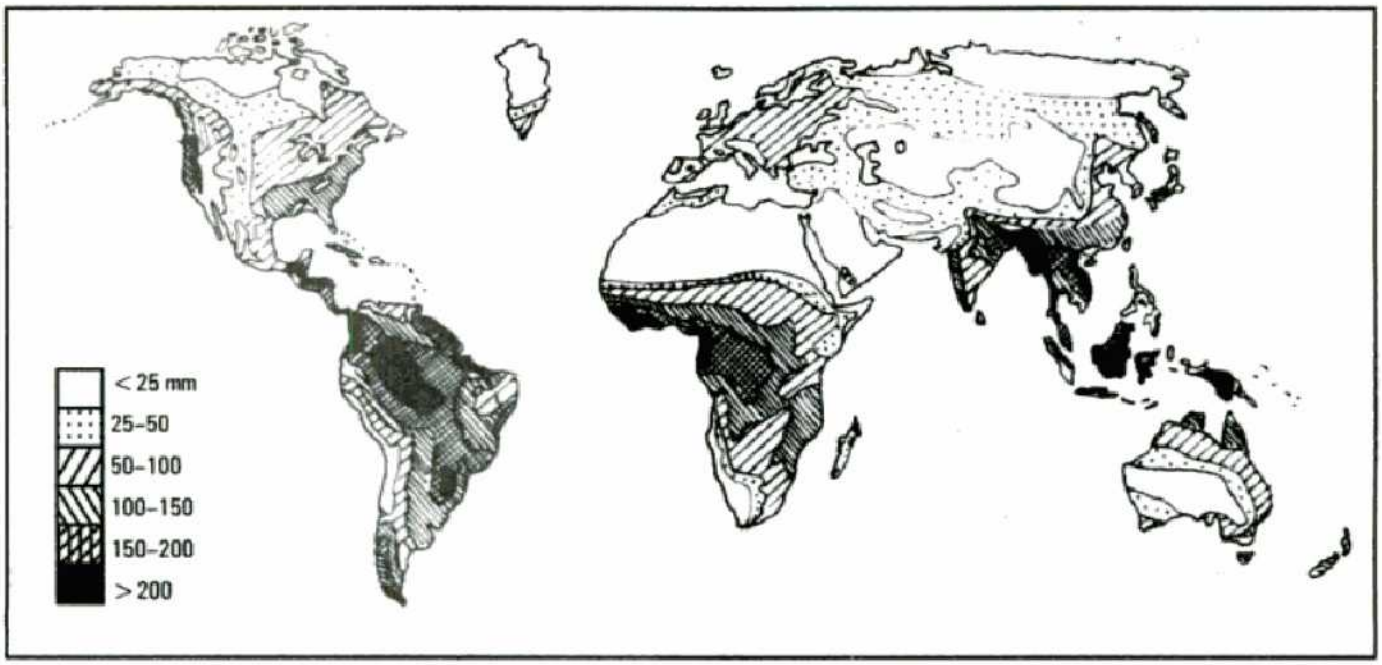

Fig. 3.43 – Mean precipitation over the Earth

There are currently several hypotheses about their origin. One suggests that it is the result of huge amounts of heat released on the sea-floor as a result of magma pouring out onto the sea floor of the Pacific Ocean. Another suggestion is that ENSO is a result of high snowfall over Asia the previous winter, i.e., when there is a lot of snow on the Eurasian land mass in a given winter, there will be much more snow- melt. A high volume of melt-water reduces the normal summer heating of the land mass. Unfortunately, it will probably take at least several more ENSO events before any hypothesis can be postulated and tested.

La Nina

When the temperature along the equator in the Pacific Ocean falls by around 4°C, it brings unusually cool weather to the eastern Pacific. The fishermen of Peru call this sudden cooling of the equatorial water La-Nina, Spanish for *'the girl'*. The name was applied to the phenomenon for the first time in 1986. La-Nina exaggerates the normal southern oscillation. During the La-Nina, the trade winds are stronger, the water off South America is colder, and water in the western Pacific near the equator is warmer than normal **(Fig. 3.46)**. In the western Pacific, surface pressures are lower and heavy rainfall occurs. In the year of La-Nina, South-East and South Asia get more summer precipitation than usual. In such a year

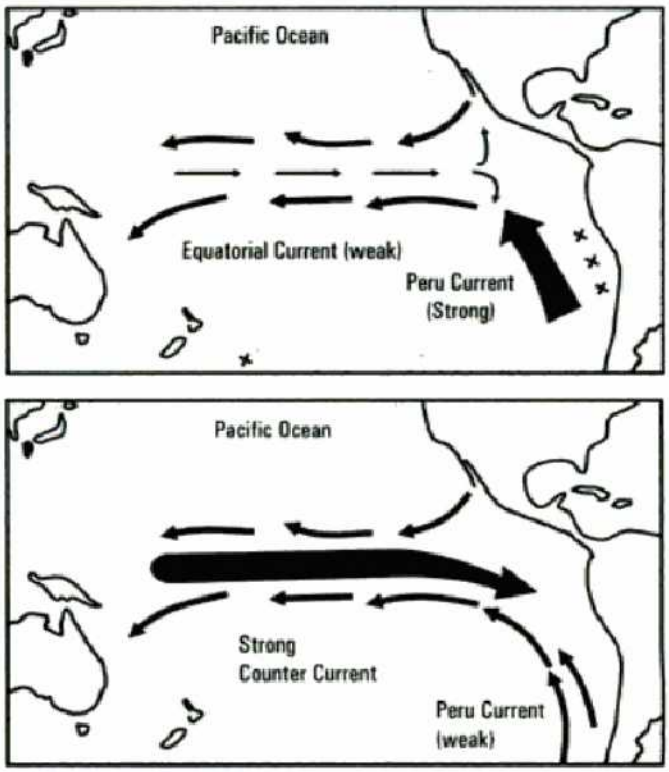

Fig. 3.44 – EL-Nino

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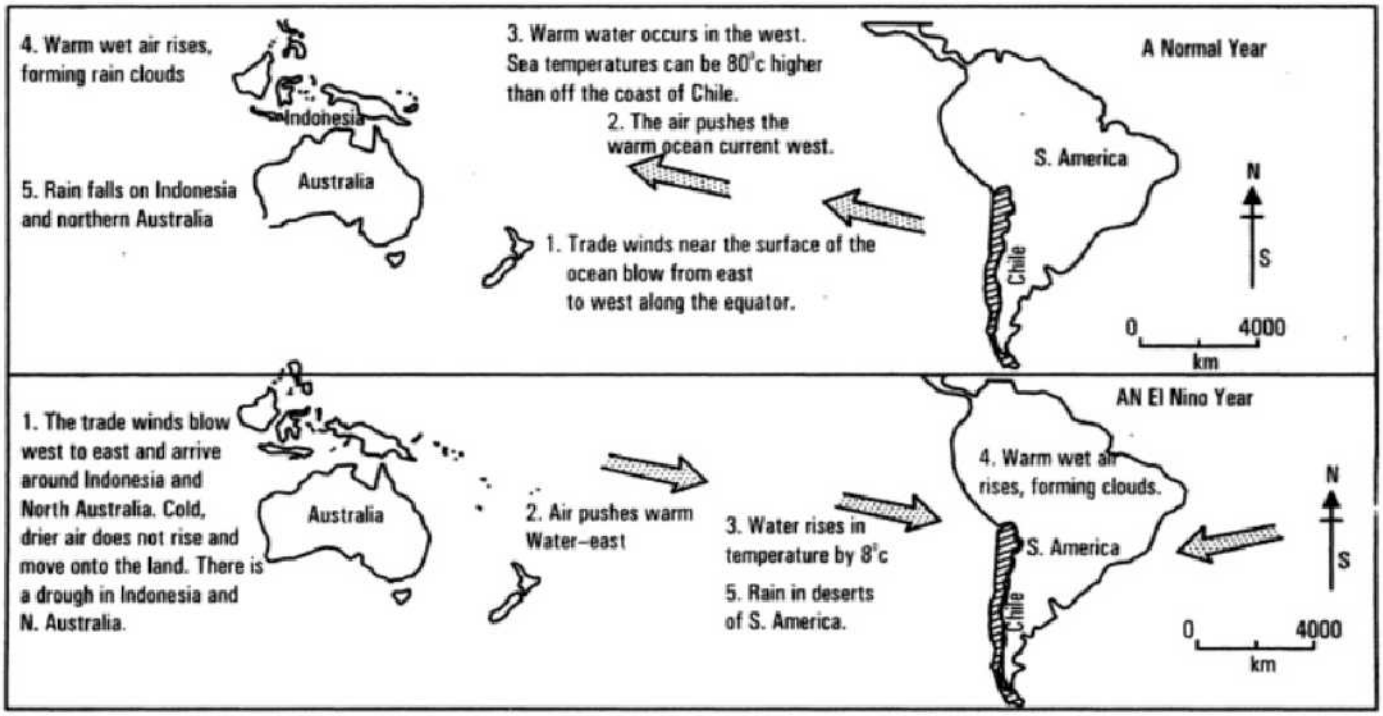
4. Warm wet air rises, forming rain clouds
Indonesia
Australia
5. Rain falls on Indonesia and northern Australia
3. Warm water occurs in the west. Sea temperatures can be 80°c higher than off the coast of Chile.
2. The air pushes the warm ocean current west.
1. Trade winds near the surface of the ocean blow from east to west along the equator.
A Normal Year
S. America
Chile
N
S
0
4000
km
1. The trade winds blow west to east and arrive around Indonesia and North Australia. Cold, drier air does not rise and move onto the land. There is a drough in Indonesia and N. Australia.
Australia
2. Air pushes warm Water–east
3. Water rises in temperature by 8°c
5. Rain in deserts of S. America.
AN El Nino Year
4. Warm wet air rises, forming clouds.
S. America
Chile
N
S
0
4000
km

Fig. 3.45 – El–Nino

the frequency of tropical cyclones is high as a result of which thousands of people get killed along the coast of Bangladesh and the eastern coast of India (Orissa, Andhra Pradesh , Tamil Nadu, and West Bengal).

Ozone Layer Depletion

Ozone is mainly confined to the stratosphere. Ozone is a molecule formed of three atoms of oxygen. Ozone forms naturally when lightning strikes through air; large quantities are generated spontaneously in the stratosphere (the uppermost layer of atmosphere). A diffuse layer of ozone mixed with other gases – the ozone layer – surrounds the world at a height of *20 to 40 kilometers* (*12 to 25 miles*).

'Harmless' synthetic chemicals released into the atmosphere–primarily chlorofluorocarbon (CFCs) used as cleaning agents, refrigerants, fire-extinguishing fluids, spray-can propellants, and insulating foams are converted by the energy of sunlight into compounds that attack and partially deplete the Earth's atmospheric ozone. The CFCs are complex synthetic molecules of chlorine, fluorine, and carbon. They are very stable (inert) under conditions of Earth's surface and they possess remarkable heat properties, making them valuable as refrigerants and as propellants in aerosol sprays.

Ozone levels in the stratosphere has decreased by at least 3% in USA, 4% in Australia, and New Zealand and 50% near the North and South Poles. The amount of depletion varies with latitude (and with the seasons) because of variations in the intensity of sunlight **(Fig. 3.47).**

The decrease in ozone alarms scientists because stratospheric ozone intercepts come of high energy ultraviolet radiation coming from the sun. Ultraviolet radiation injuries living things by breaking strands of DNA and unfolding protein molecules. Species normally exposed to sunlight have evolved defenses against average amount of ultraviolet radiation, but increased amounts could overwhelm these defenses. Land plants such as soybeans and rice would be subjected to sunburn that decreases their yields. Even plankton in the upper most two meters of ocean would be adversely affected. Recent researches

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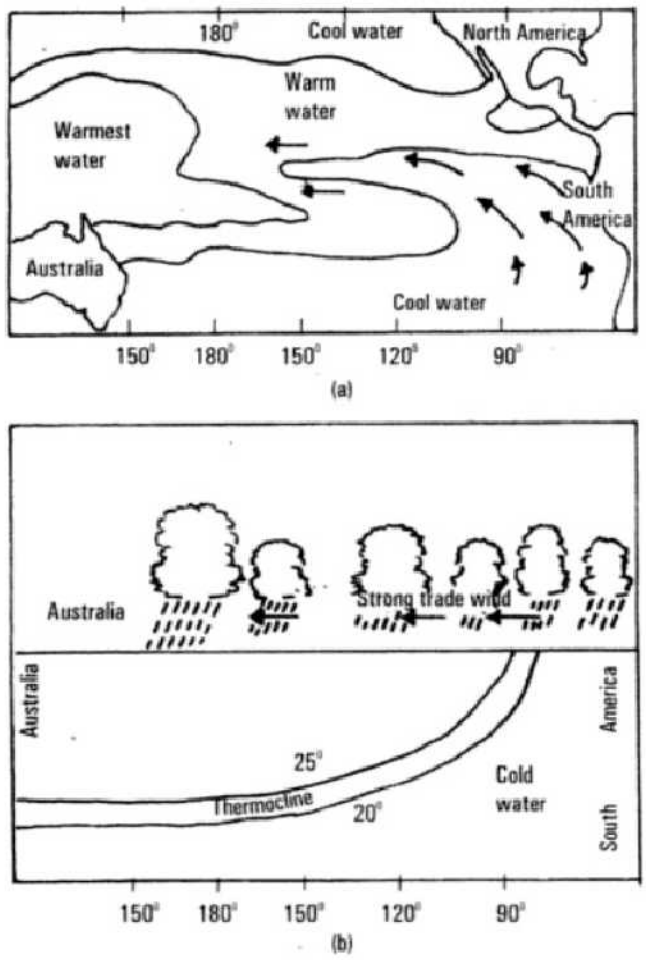

Fig. 3.46 (a) – Ocean temperatures and wind direction during La-Nino

(b) The thermocline reaches the surface for west of South America. The warm water is limited to the western Pacific Ocean. This restricts cloud cover and precipitation to the far western Pacific Ocean

indicate an alarming decrease in phytoplankton primary productivity of between 6% and 12% in the coastal waters around Antarctica.

The human beings would not escape the adverse effects of ozone depletion. About one per cent decrease in atmospheric ozone would probably be accompanied by a 5% to 7% increase in human skin cancer. Strong ultraviolet light can also suppress the immune system and cause eye cataracts.

The world community is seriously concerned about the adverse effects of ozone depletion and the production of CFC gases is being reduced. Unfortunately, the CFC gases stay in the atmosphere for up to 110 years and so, their damaging effect will continue. It may already be too late.

Climatic Change

The Earth is currently in a warm phase between ice ages. Warmer temperatures result in higher sea levels as more of the polar ice caps melt. Most of the world's population lives near sea coasts, so any changes which might cause sea levels to rise, could have a potentially disastrous impact.

The Greenhouse Effect

The greenhouse effect is a natural phenomenon. Gases such as carbon are known as "greenhouse gases" because they allow shortwave radiation to enter the Earth's atmosphere, but help to stop long-wave radiation from escaping. This traps heat, raising Earth's temperature. An excess of these gases, such as that which results from burning of fossil fuels, helps trap more heat and can lead to global warming.

The most important greenhouse gases are water vapour and carbon dioxide **(Fig. 3.48)**. Their presence in the atmosphere allows the Earth to maintain an average temperature of approximately 15°C. Without them, the surface temperature of the planet would be about -19°C, and the Earth could not support life. Consequently, it is clear that we owe our very existence to the greenhouse effect. With the onset of the Industrial Revolution, however, the CO_2 content of the air began to rise, and people began to worry that this phenomenon might have a 'dark side' we had not anticipated. Some of the experts predict that the doubling of the atmospheric CO_2 concentration will enhance the planet's natural greenhouse effect to such an extent that it will lead to catastrophic global warming, which would melt the polar ice caps, flood coastal lowlands, produce simultaneous floods and droughts, cause havoc with agriculture, and lead to all manner of economic, social and political instability. Because of these dire potential consequences, CO_2 is often portrayed as a pollutant in the popular media.

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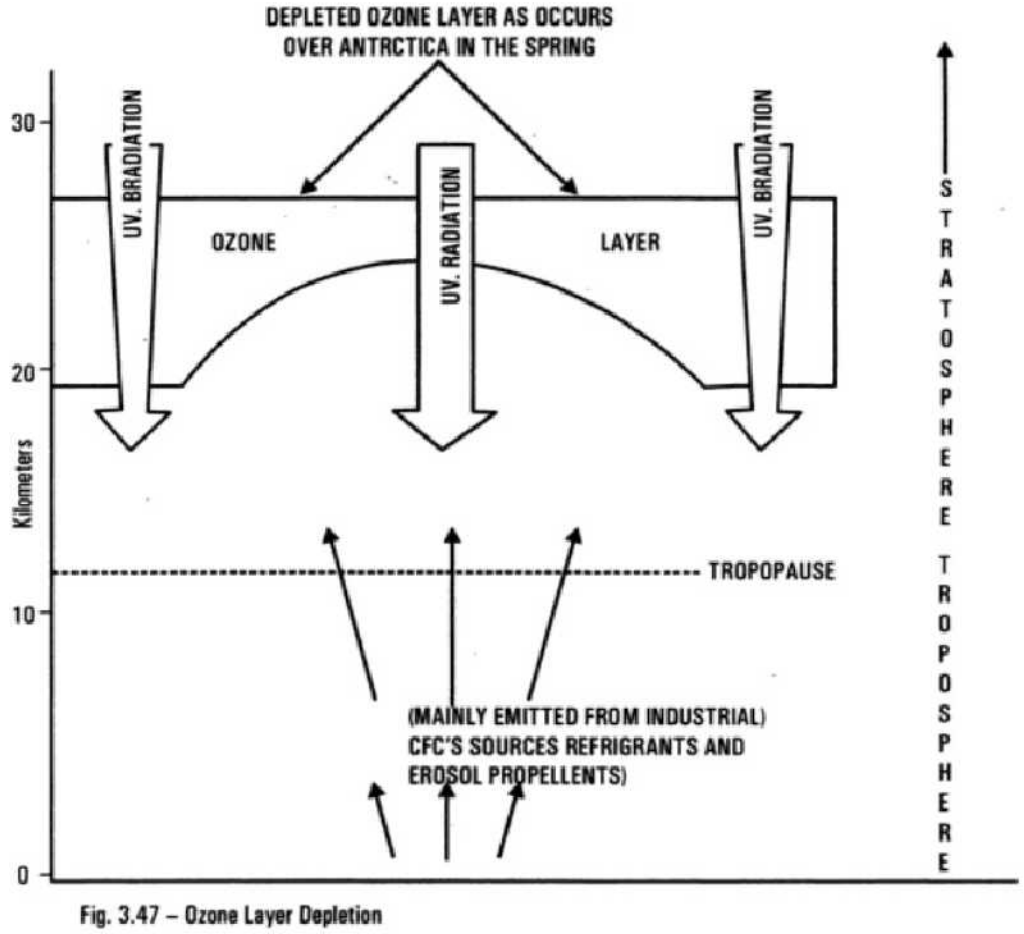

Fig. 3.47 – Ozone Layer Depletion

Fig. 3.47 – Ozone layer depletion

The scientists are trying to determine whether increasing concentration of atmospheric greenhouse gases will have any effect on global temperature or climatic patterns. Scientists who use computer models to study these questions commonly report that a temperature rise of 2° to 4°C will result from a doubling of temperature's CO^2 content, leading to catastrophic events such as the melting of Earth's polar ice caps, which could produce widespread flooding and famine. Consequently, the greenhouse effect has become a topic of both scientific and political debate; and will probably remain so for years to come.

Global Warming

The average temperature of the Earth is about 14°C. The Earth's temperature, however, fluctuates slowly over time. The global temperature trend has been generally upward in the last 18,000 years since the last ice-age, but the rate of increase has recently accelerated **(Fig. 3.49).** This rapid warming may be the result of an enhanced *greenhouse effect,* the trapping of heat by the atmosphere. Glass in a greenhouse is transparent to light but not to heat. The temperature inside a greenhouse rises because the heat is unable to escape. On Earth greenhouse gases – carbon dioxide, methane, CFCs, and others — take the place of glass. Heat that would otherwise radiate away from the planet is absorbed and trapped by these gases, causing a rise in surface temperature **(Fig. 3. 50).**

Evidence of Global warming : There is a unanimity amongst most of the scientists that the Earth is warming at an unusual rate. There are many temperature dependent phenomena that indicate the Earth is warming. Some of important proofs of global warming are as follows:

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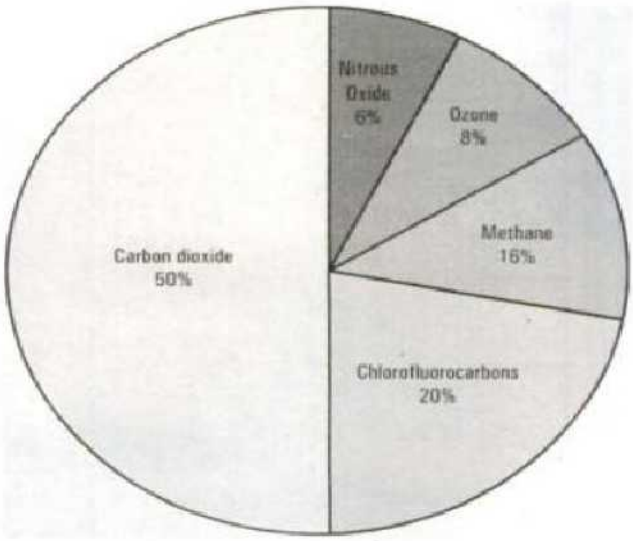

Fig. 3.48

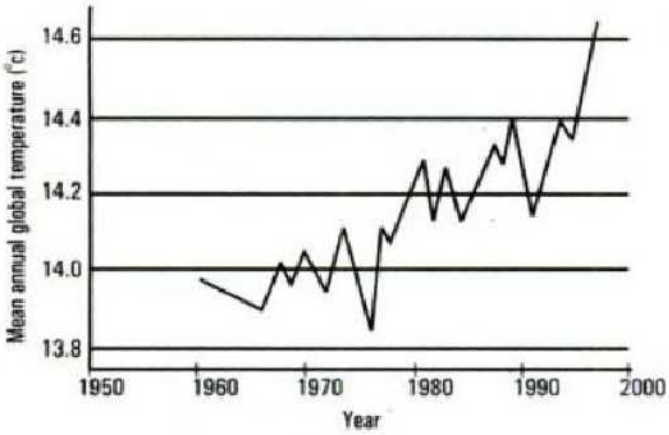

Fig. 3.49

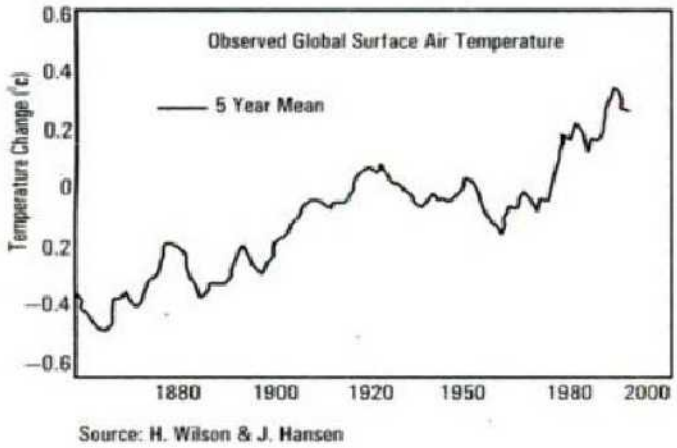

Fig. 3.50 – Increase in global surface air temperature

1. Antarctica's ice sheets are breaking up.
2. Earth's mountain glaciers are melting. Glaciers of the Alps Mountains of Europe shrank by about 50% in the 20th century. Bering Glacier in Alaska is retreating. Garhwal Himalaya glaciers are rapidly retreating.
3. Sea level is rising.
4. The temperature of global ocean is rising.
5. Northern Hemisphere's permafrost is melting.
6. Arctic pack ice is thinning and retreating.
7. The tree-line in mountain ranges is moving upward.
8. Many tropical diseases are spreading towards the poles and the higher elevations in the tropics.
9. Snowfall was recorded in the desert of Dubai and Abu-Dhabi in 2005.
10. Vegetation appearing on the free slopes of Antarctica.
11. The frequency of El-Nino years is increasing.
12. 1998 was the warmest year of record.
13. Seven of the 10 warmest years of record occurred since 1990.
14. The 1990s was the warmest decade on record.
15. The 20th century was the warmest century of the millennium.
16. The population of Adelie penguin on Antarctica dropped 40% in the last century
17. The corals are dying at an unprecedented rate. The dying corals is attributed to the process caused by bleaching, which occurs when temperatures become abnormally high. The bleaching is actually the result of the death of microscopic algae that both colour and feed the coral.

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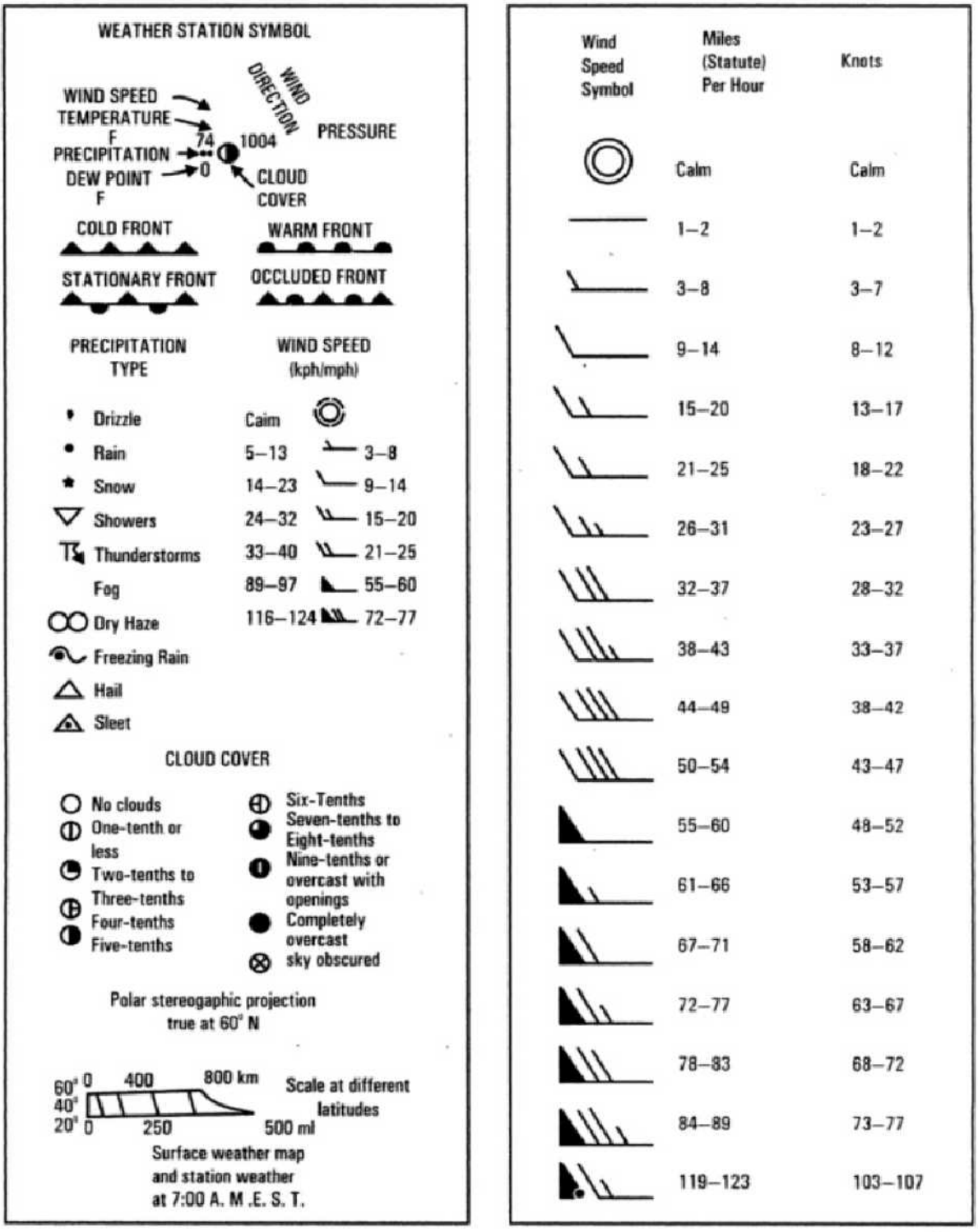

Fig. 3.51 – Forms of meteorological symbols, approved by the International Meteorological Organisation, Warsaw, 1935

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***Table 3.2:** Some Technical Terms of Climatology.*

Isoline	*Lines of*
Isallobar	Equal pressure tendency showing similar changes over a given time.
Isamplitude	Equal amplitude variation.
Isanomaly	Equal barometric pressure.
Isobar	A line on a map connecting points having the same atmospheric pressure.
Isocryme	Equal lowest mean temperature for specified period (e.g. coldest month)
Isohel	Equal sunshine.
Isohyet	Equal amounts of rainfall.
Isokeraun	Equal thunderstrom incidence.
Isomer	Equal average monthly rainfall expressed as percentage of the annual average.
Isoneph	Equal degree of cloudiness.
Isonif	Equal snowfall.
Isophene	Equal seasonal phenomena (e.g. flowering of plants).
Isoryme	Equal frost incidence.
Isoterp	Equal physiological comfort.
Isotherm	Equal temperature.

Source: Jone E., et al.2003, **Climatology: An Atmospheric Science,** *Pearson Education*

Weather

Weather is a condition of the atmosphere at a given time and place. Weather involves temperature, precipitation, humidity, wind and associated factors.

Climate

The long term atmospheric characteristics of a specified area. It is a summary of mean weather conditions over a time period usually based on 30 years of record. Climates are largely determined by location with respect to land and sea-masses, to large scale patterns in the general circulation of the atmosphere, latitude, altitude, and to local geographical features. The climatic characteristics are usually represented by numerical data on temperature, pressure, wind, rainfall and humidity.

Temperature

Temperature is a measure of how hot or cold the air is near Earth's surface.

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Terms to Remember

Anticyclone: A dynamically or thermally caused area of high atmospheric pressure with descending and diverging air-flow.

A wet–day: When at least 1 mm of rainfall is recorded.

Convection: Vertical transfer of heat from one place to another through the actual physical movement of air; involves a strong vertical motion.

Convectional rainfall: A form of rainfall induced when warm, moist air is heated at the ground surface, rises, cools and condenses to form water droplets and eventually rainfall.

Dew-point temperature: The temperature at which a given mass of air becomes saturated, holding all the water it can hold. Any further cooling or addition of water vapour results in active condensation.

Cumulonimbus: These are thunder clouds which result into torrential rainfall.

Horse latitudes: Subtropical high pressures on oceans.

Katabatic: Air drainage from elevated regions, flowing as gravity winds.

Normal Lapse Rate: The average rate of temperature decrease with increasing altitude in the lower atmosphere; an average value of 6.4°C per km, or 1000 m.

Orographic lifting: The uplift of migrating air masses in response to the physical presence of mountain, a topographic barrier. The lifting air cools adiabatically as it moves upslope; may form clouds and produce increase precipitation.

Orographic precipitation: The precipitation occurring because the physical presence of mountain which obstructs the moisture-laden air-mass.

Roaring forties: Blowing in and around 40°S, these are the fast westerly winds. In the higher latitudes, they are known as furious fifties, shrieking sixties because of their violent speed.

Squall: A very shortlived wind.

Thermal equator: A line joining the points with highest mean temperature.

Tornado: An intense, destructive cyclonic rotation, developed in response to extremely low pressure, associated with mesocyclone formation.

Tyndal effect: Scattering of light by dust particles.

Typhoon: A tropical cyclone in excess of 65 knots (74 mph) that occurs in the western Pacific, mostly along the China coast.

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Table 3.3: Weather Instruments

Weather Instrument	*Function*
Antinometer	Solar radiation
Altimeter	Measuring of altitude (height)
Anemometer	Wind speed
Atmometer	An instrument for measuring the rate of evaporation
Barograph	Continuous recording of atmospheric pressure
Barometer	Pressure
Cathetometer	Height
Cryometer	Very low temperatures
Evaporimeter	Rate of evaporation
Fathometer	Ocean depth
Hydrometer	Specific gravity of liquid
Hygrometer	Relative humidity
Hypsometer	Absolute height above the sea level
Lysimeter	Actual evapotranspiration
Manometer	Pressure of gases
Nephoscope	Height, movement and velocity of clouds
Photometer	Luminous intensity of the source of light
Psychrometer	Relative humidity
Pyrometer	Very high temperature
Radio micrometer	Heat radiation
Raingauge	Precipitation
Salinometer	Salinity of solution
Solarimeter	Intensity of solar radiation
Thermometer	Temperature
Thermostat	Regulates temperature to a particular point
Wet and Dry Bulb Thermometer	Relative humidity
Wind-vane	Wind direction

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Chapter Four

Oceanography

Chapter Concept

- **Oceans**

The hydrosphere is the total mass of water on the surface of our planet. The Earth's oceans and seas cover more than 367 million sq km, that is twice the surface of Mars and nine times the surface of the Moon.

About 98% of the water is in the ocean; 2% is in streams, lakes, ground-water, and glaciers. Approximately 70.8% of the Earth is covered with water and 29.2 per cent is land area. Thus, it is for the good reason that Earth has been called *'the water planet'*. It has been estimated that if all the irregularities of the Earth's surface were smoothed out to form a perfect sphere, a global ocean would cover the Earth to a depth of *2.25 km*. It is this great water mass that makes the Earth unique. Water permitted life to evolve and flourish on the Earth and, therefore, every inhabitant on the Earth is directly or indirectly controlled by it.

Beneath the ocean waves lies the biggest and most unexplored landscape on the Earth. Here are coral reefs, enormous open plains, deep canyons, and the longest mountain range on the Earth – the *Mid-Atlantic Ridge*–which stretches almost from pole to pole.

Oceans

Oceans water cover about 70.8 per cent of Earth's surface. There is only one world ocean, but the continents divide the ocean into five distinct parts, i.e. : (i) Pacific Ocean, (ii) Atlantic Ocean, (iii) Indian Ocean, (iv) Arctic Ocean, and (v) Southern Ocean (Antarctic Ocean).The greater parts of the oceans, the ocean basins, are relatively young having evolved within the last 80 million years. One of the most recent plate collision, between the Eurasian and African plates, created the present day arrangement of the continents and oceans. The main features of the Earth's solid surface as percentage of the planet's total surface have been shown in **Fig. 4.1.**

Coasts

The total length of the Earth's coastlines is more than 500,000 km, that is the equivalent of 12 times around the globe. A high percentage of the world's population live in coastal zones. Of the ten most populated cities on the Earth, eight are situated on deltas, estuaries, or the coast.

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Ocean Relief or Major Features of Oceanic Lithosphere

The oceanic crust differs strikingly from the continental crust with respect to rock types, structure, landforms, age and origin. The major features of the ocean floor are: continental shelf (margin), (2) continental slope, (3) continental rise, (4) abyssal floor (deep ocean basins), (5) oceanic trenches, (6) oceanic ridges, and (7) seamounts.

Continental Margin

The submerged part of the continent is known as continental margin. Geologically it is part of the continent and not part of the ocean basin. The continental margin includes (a) continental shelf and (b) continental slope.

1. Continental Shelf

It is the submerged margin of continental mass extending from the shore to the first prominent break in slope. Some shelves reach a depth of over 500 m, but 200 m is often conveniently used as a depth limit. The mean width is about 70 km, but there is a marked variation between different coasts. It is estimated that the continental shelves cover approximately 5 per cent of the Earth's surface. The vast majority of sea exploitation – including fishing and gas and oil-drilling – occurs on the continental shelf. Coastal areas are in the greatest danger of pollution.

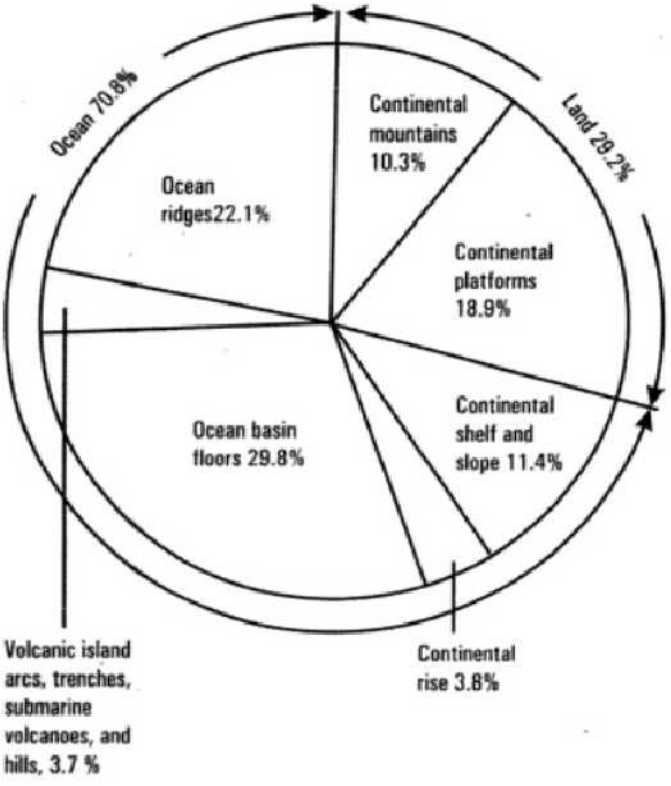

Fig. 4.1 – Features of the Earth's solid surface, shown as percentages of the planet's total surface

2. Continental slope

The slope that extends from the continental shelf down to the ocean deep is known as continental slope. In some areas, such as off eastern North America, the continental slope grades into the more gently sloping continental rise. At present continental shelves and continental slope constitute about 11.4 % of the Earth's solid surface out of which 6.4 per cent is the area of continental slope **(Fig. 4.1)**.

Continental Rise

This is the gently sloping seafloor lying at the foot of the continental slope and leading gradually into the abyssal plain. They cover 3.8 per cent of the total area of the oceans.

Abyssal Floor

This is the large expanse of very smooth, flat ocean floor found at depths of 3000 to 5500 m. The abyssal plains cover from 80 to 85% of the floor of the Pacific Ocean. In fact, they are the most widespread landforms on the Earth **(Fig. 4.2).**

Oceanic Trench

The narrow, deep depression in the seafloor representing the line of subduction of an oceanic lithospheric plate beneath the margin of a continental lithospheric plate; often associated with an island arc. The ocean trenches are the lowest areas on Earth's surface. The Mariana Trench, in the Pacific Ocean, is the deepest part of the world's oceans –11022 m below sea level, and many other trenches are more than 8000m deep. Some of the important trenches of the oceans are given below **(Fig. 4.3).**

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North Pacific Ocean

Mariana Trench (11022 m), Ramapo Deep or the Japan Trench (10,554 m), Aleutian Trench (10,498 m), Philippines Trench (10,475 m).

South Pacific Oceanm

Kermadec-Tonga Trench (the steepest trench of the world), New Hebrides Trench, Peru-Chile or Atacama Trench (7635 m).

North Atlantic

Puerto Rico Trench (8358 m), Romanche Trench (7631 m).

Indian Ocean

The Sunda Trench (Sumatra) and Java Trench (7454 m).

Oceanic Ridge

The oceanic ridge is perhaps the most striking and important feature on the ocean floor. They cover about 22.1 per cent of the surface of the oceans. Their total length is about 66 thousand kilometers. The oceanic ridge extends continuously from the Arctic basin, down the centre of the Atlantic Ocean, into the Indian Ocean, and across the South Pacific. The oceanic ridge is essentially a broad, fractured swell and generally more than 1400 km wide. Its higher peaks rise as much as 3000 m above the ocean floor. The Mid-Atlantic Ridge, having a length of about 14,450 km, extends from Iceland in the north to *Bouvet Island* in the south. The oceanic ridges are formed by lava which erupts beneath the sea and cools to form solid rock. This process mirrors the creation of volcanoes from cooled lava on the lava. The ages of the sea floor rocks increase in parallel bands outward from central ocean ridges. The major oceanic ridges of the world have been shown in **Fig. 4.4.**

Island Arcs

These are curving chains of volcanic islands and seamounts that are always found paralleling the concave edge of trenches. They are formed by the tectonic activity of subduction. Some of the important island arcs are the Aleution Islands, the Lesser Antilles, and the Mariana Islands.

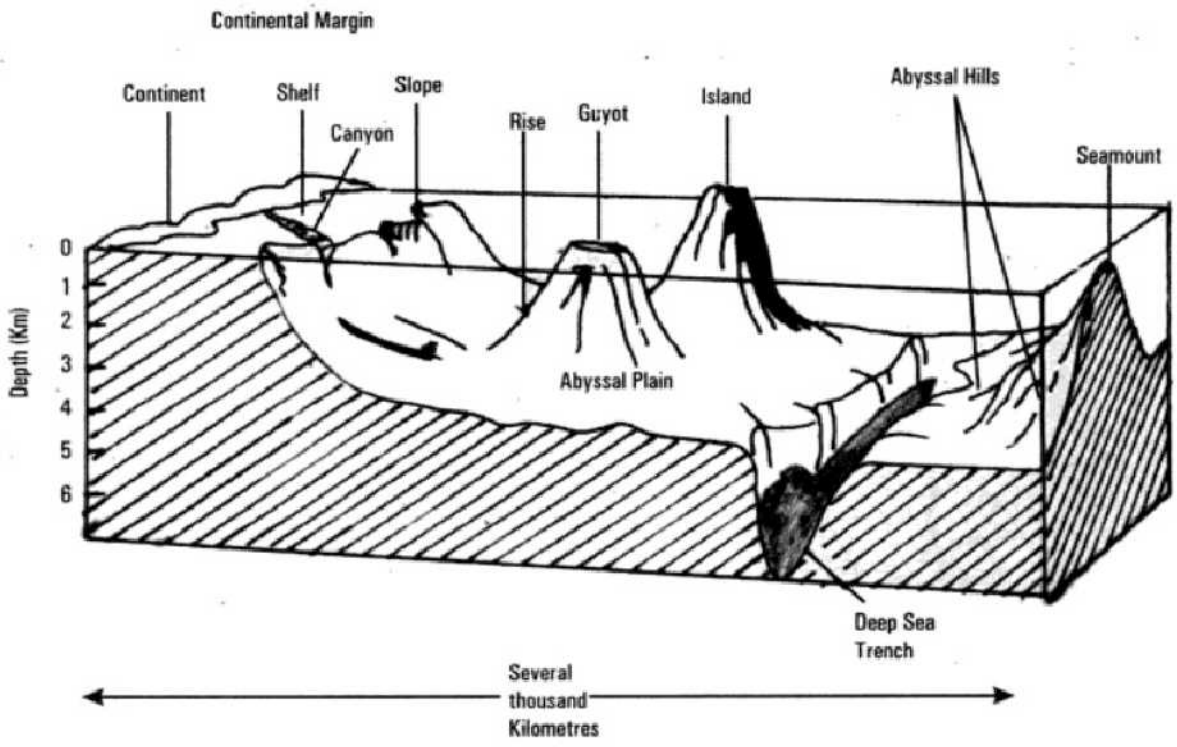

Fig. 4.2 – Marine environment

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Seamounts

It is circular or elliptical projection form the seafloor, more than one kilometer in height, with a relatively steep slope of 20° to 25° **(Fig. 4.2).**

Guyot

Guyot is a flat topped, submerged, inactive volcano. They are tall enough to approach or penetrate the sea surface **(Fig. 4.2).** Generally they are confined to the west-central Pacific.

Black Smokers

The black smokers are vents in the ocean floor which disgorge hot, sulfur-rich water from deep in the Earth's crust. Despite the great depths, a variety of life-forms have adapted to the chemical-rich environment which surrounds black smokers.

Hypsographic Curve of the Earth Surface

This is a graph of the area of the Earth's surface above and given elevation or depth above or below the sea level. It may be observed from **Fig. 4.5** that the highest mountain peak (Mt. Everest) is 8848 m, while the greatest ocean depth is 11,022 m. The average elevation of the exposed land is 840 m and the average depth of the oceans is -3790 m.

Temperature of the Oceans

Oceans absorb more than 80% of the solar radiation that reaches the Earth. Moreover, water has remarkable capacity for absorbing heat. The upper most 10 % of the oceans contain more heat than the entire atmosphere.

The temperature of the oceans is not uniform. It differs from latitude to latitude and from surface to bottom. The major determinants of oceans temperature are:

(i) Latitude: The surface temperature of the oceans declines from equator towards the pole as on equator the Sun's rays are vertical and slanting on the poles.

(ii) Prevailing Winds: Wind direction (trade and anti-trade winds) largely affects the surface distribution of temperature of the oceans.

(iii) Unequal Distribution of Land and Water: The Northern Hemisphere has more land area than that of the Southern Hemisphere. Consequently, the oceans of the Northern

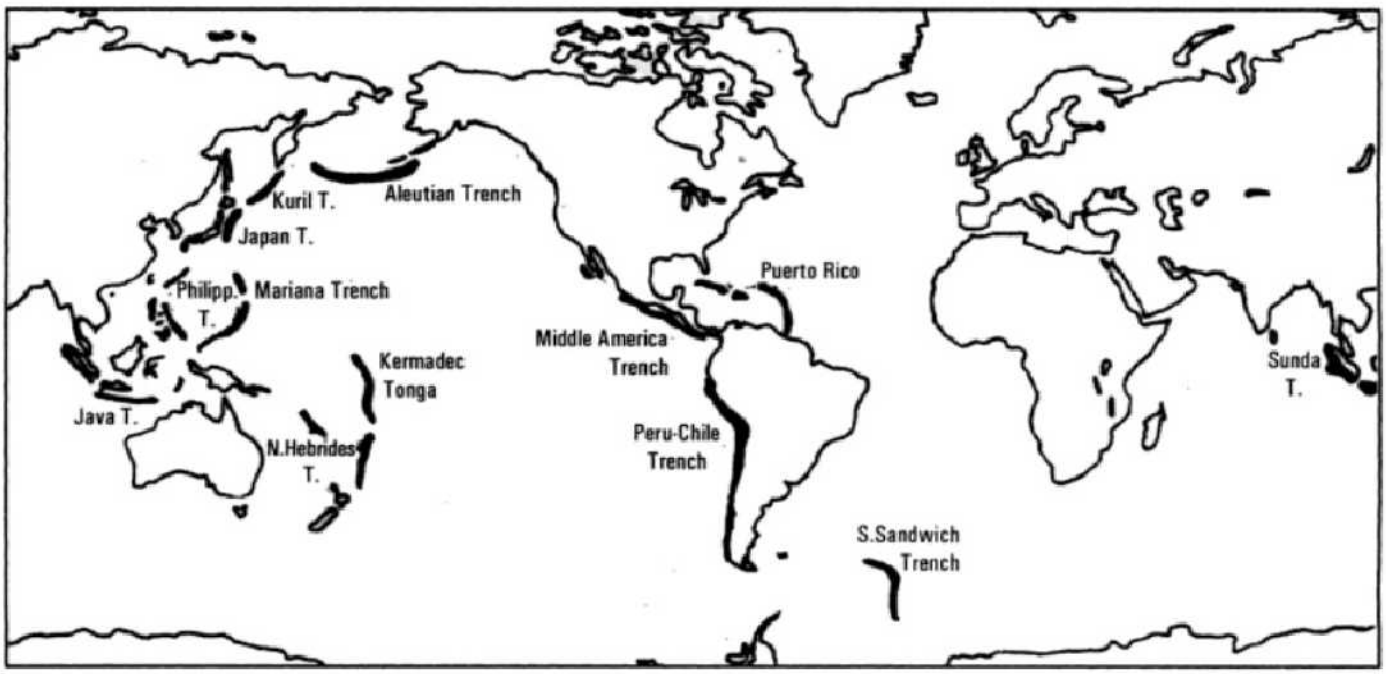

Fig. 4.3 – Major ocean trenches of the world

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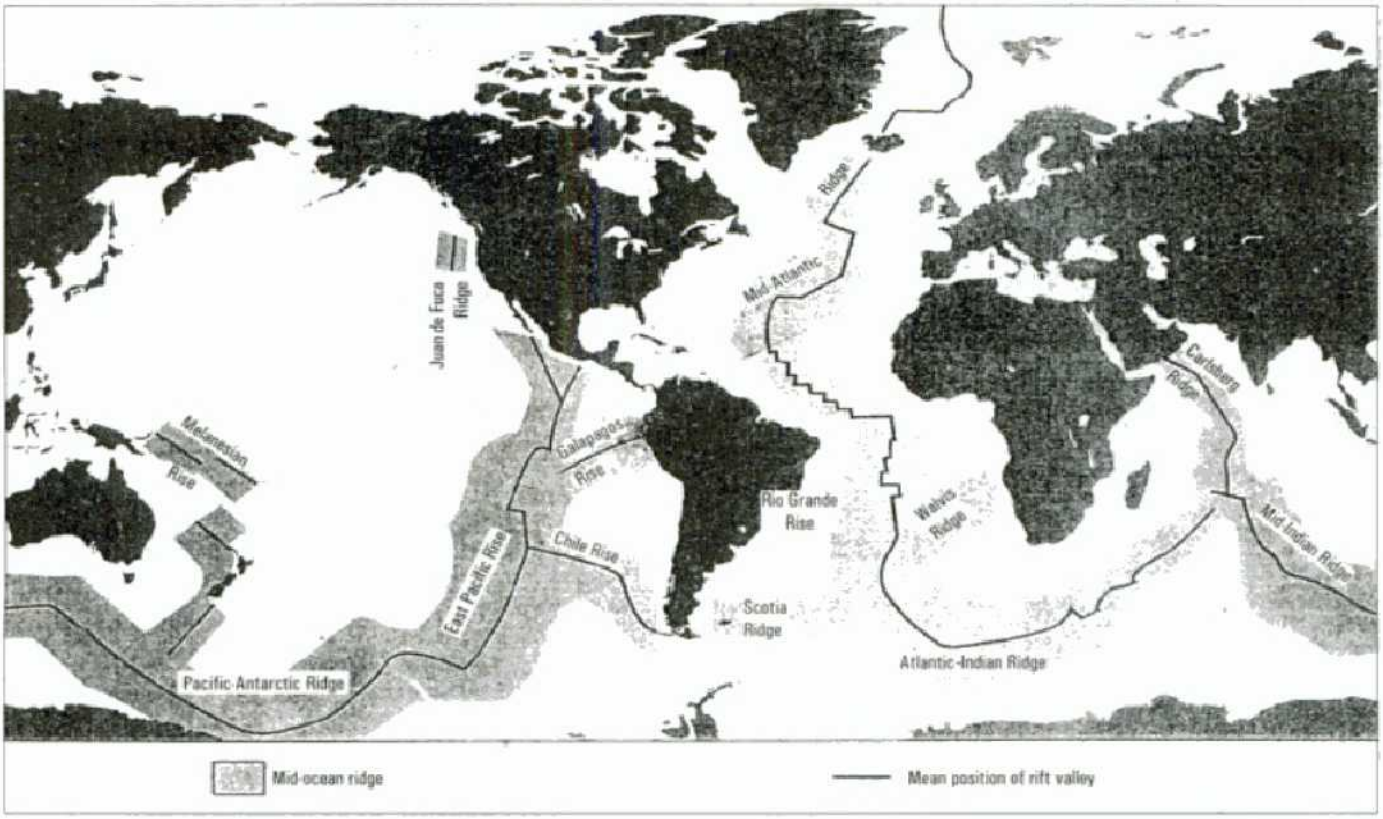

Fig. 4.4 – The oceanic ridge system

Hemisphere are warmer than that of the Southern Oceans.

(iv) Evaporation Rate : The volume of water that evaporates each year from the surface of ocean is equivalent to 350,000 cubic kilometers. The evaporation rate is however, not uniform in different latitudes.

(v) Density of Water: The density of water is mainly a function of its salinity and temperature. The density of water differs from latitude to latitude. In the areas of high salinity, there is relatively high temperature and vice-versa.

(vi) Ocean Currents: Surface temperature of the oceans are also controlled by warm and cold currents. The presence of a warm water current increases the temperature and the rate of evaporation. Consequently, the region records more rainfall, while the cold water current reduces the temperature of the moisture-laden wind. The coast along with a cold water current flows record more fog, but less precipitation.

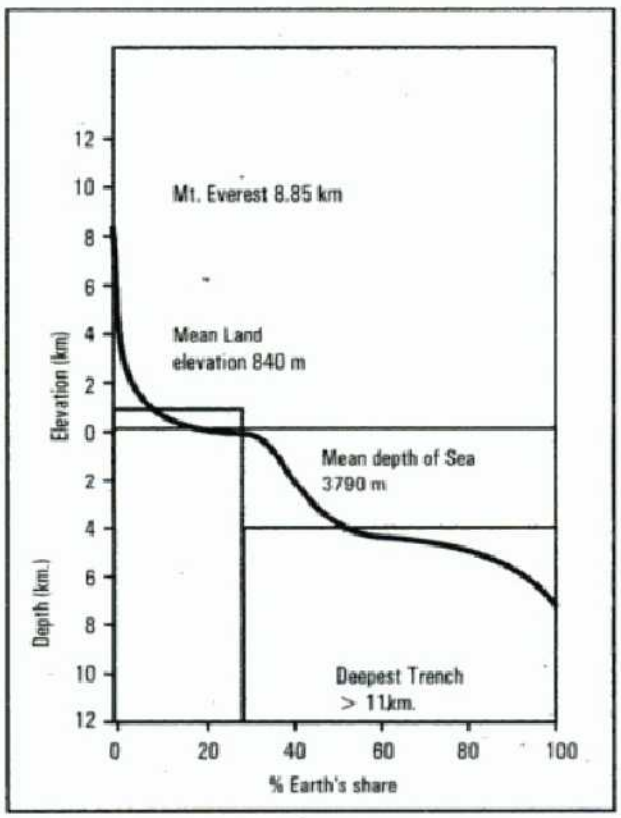

Fig. 4.5 – The hypsographic curve

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(vii) Local Factors: Submarine ridges, local weather conditions like storms, cyclones, winds, fogs, cloudiness, rate of evaporation, lapse rate, condensation, and precipitation also affect the distribution of temperature of the oceans.

Horizontal Distribution of Temperature

In general, the temperature of the surface water in the lower latitudes is about 26°C which decreases towards poles. The oceans of the Northern Hemisphere record an average temperature of 19.4°C. In the Northern Hemisphere the average temperature reads 22°C at 20° latitude, 14°C at 40° latitude, and 0°C near the poles. In the Southern Hemisphere, the average temperature is only 16.1°C. **(Fig. 4.6).**

The maximum and minimum annual temperatures of ocean water in the Northern Hemisphere are in the months of August and February, respectively. The average annual range of temperature is about 12°C. The highest annual range of temperature is recorded in the North Atlantic Ocean. Moreover, the annual range of temperature is higher in the inland seas as compared to the open oceans.

Vertical Distribution of Temperature

Both energy and sunlight decrease with depth in the oceans. Only about 45% of light energy striking the ocean surface reaches a depth of about one meter, and only 16% reaches 10 meter depth. On the basis of temperature the ocean depths may be divided into the following three zones:

1. Surface Zone or Mixed Zone (Photic or Europhic Zone): It is the upper layer of the ocean. In this layer, the temperature and salinity are relatively constant. It contains about 2% of the total ocean volume of water, and its depth is only about 100 meter **(Fig. 4.7).**

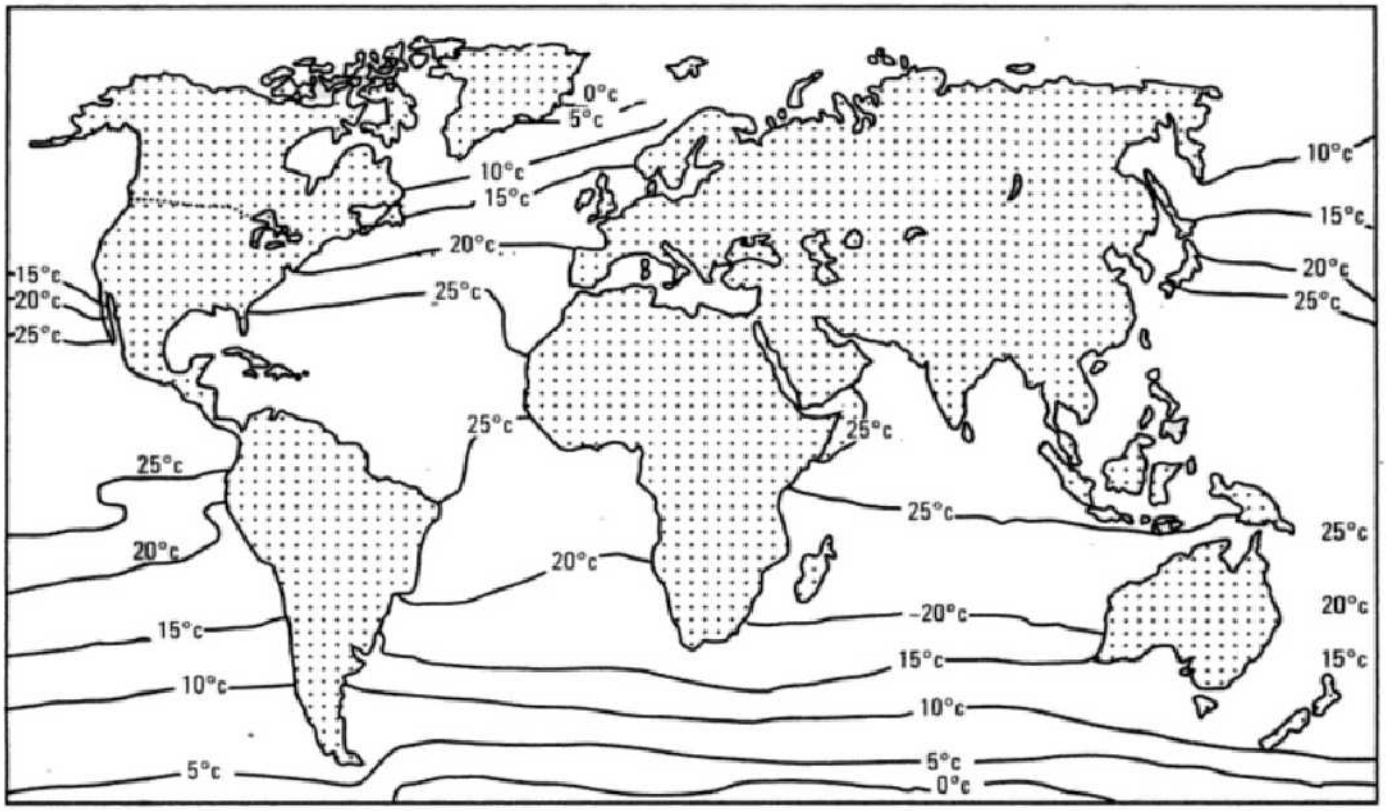

Fig. 4.6 – Oceans: Horizontal distribution of temperature

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2.Thermocline or (Pycnocline): It lies between 100 metres and 1000 metres. It contains about 18% of the total volume of oceanic water. There is a steep fall of temperature in this zone. The density of water increases with increasing depth.

3.The Deep Zone: This zone lies below 1000 meters in the mid-latitudes. The deep zone contains about 80% of the total volume of ocean water. Temperature near the bottom is always more than the freezing point – around one or two degree C.

Salinity

Salinity is a measure of dissolved solids in seawater, usually expressed in grams per kilogram or parts per thousand by weight. The standard sea water has a salinity of 35% at 0°C (32°F). In water of the ocean, 96.5% is water, and 3.5% dissolved salts

The most common substance in the sea water is sodium chloride or salt. The chemical composition of salts of oceans is given in the **Table 4.1**.

***Table 4.1:** Chemical Composition of Sea Water*

Salt	*Percentage*
Sodium chloride	2.6
Magnesium chloride	0.3
Magnesium sulphate	0.2
Calcium sulphate	0.1
Potassium chloride	0.1
Potassium bromide	0.01
Other elements	0.01

Sources of Salinity

Much of the dissolved materials (salts) of the seas/oceans originated from land which was carried to the oceans by rain, running water, ground water, wind, sea-waves and glaciers. Some of the salts, however, have their origin in the deeper layers of the Earth. The volcanic lava adds to the salinity of the oceans. In addition to these, the dead and decomposed organic life adds to the salinity of the oceans.

Determinants of the Salinity of the Oceans

The distribution of salinity of the oceans depends on the rate of evaporation, temperature, precipitation, cloudiness, influx of fresh water, winds, and ocean currents:

(i) Evaporation: In general, higher the rate of evaporation, higher the salinity of oceans. The highest rate of evaporation is recorded along the Tropic of Cancer, especially in the Red Sea and the Persian Gulf. Consequently, these water bodies have one of the highest salinity in the world.

(ii) Temperature: There is a direct relationship between temperature and salinity of the oceans. In general, the higher, the temperature, the higher, the salinity of the oceans. The Torrid Zone has higher salinity as compared to the Frigid Zone of the world.

(iii) Precipitation: The amount of precipitation is inversely related to salinity. In general, the higher, the precipitation, the lower, the proportion of salinity. The oceans of the equatorial region, recording the heavy rainfall throughout the year, have relatively low salinity.

(iv) Ocean Currents: Ocean currents also affect the spatial distribution of salinity in the ocean

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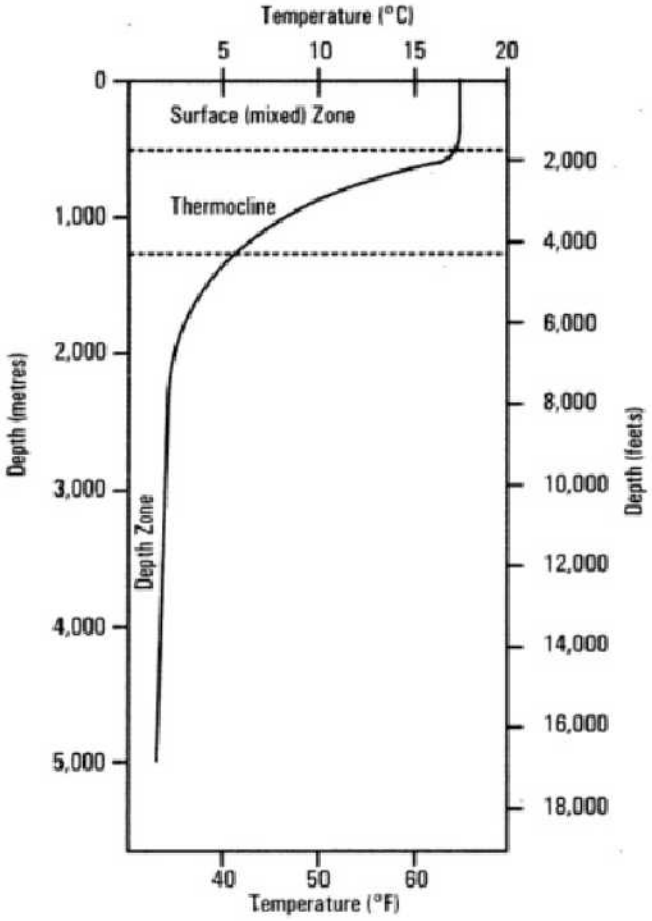

Fig. 4.7 - Typical temperature variation with deep ocean at Mid-latitude

bodies of the world. The equatorial warm water currents drive away salts from the eastern coastal areas and accumulate them along the western coastal areas of the oceans. The Gulf Stream and the North Atlantic Drift increase the salinity in the North Sea and the North east Atlantic Ocean.

(v) Influx of Fresh (River) Water: Comparatively low salinity is found along the mouth of the Amazon, Congo, and Ganga deltas mainly due to the influx of fresh water.

Horizontal Distribution of Salinity

The salinity of the oceans decreases on both sides of the tropics. For example, the average salinity along the equator is about 35‰, while along the Tropic of Cancer, it is over 36‰.

On the basis of salinity, the oceans and seas of the world may be divided into the following categories:

(i) Seas having Salinity above Normal: The salinity of the Red Sea is about 39 to 41‰, Persian Gulf 38‰ and the Mediterranean Sea 37 to 39‰.

(ii) Seas with Normal Salinity: The Caribbean Sea, Gulf of Mexico, Gulf of California, and Yellow Sea have a salinity between 35‰ and 36‰.

(iii) Seas having Salinity below Normal: The Arctic Ocean, Antarctic Ocean, Bering Sea, Japan Sea, Baltic Sea, etc. have low salinity(21‰).

Vertical Distribution of Salinity

So far as the vertical distribution of salinity is concerned, no definite trend is found and, therefore, no generalisation can be made. In general, with increasing depth of sea water, both the trends of increase and decrease of salinity are found. The vertical distribution of salinity is plotted on T-S Diagram, advocated by Helland-Hensen. The various patterns of salinity in the Halocline, Thermocline and Pycnocline have been shown in **Fig. 4.8**.

The characteristics of vertical distribution of salinity may be summarised as follows:

(i) The salinity of the oceans increases with increasing depth.

(ii) Salinity is low at the surface water in the equatorial water.

(iii) In the middle latitudes, the salinity increases with increasing depth.

Ocean Deposits

The sediments, derived from various sources, deposited at the oceans floors are known as ocean deposits. The main sources of ocean deposits are:

(i) Terrigenous: Gravel, sand, silt, clay, mud, etc. Sediments derived from the land and

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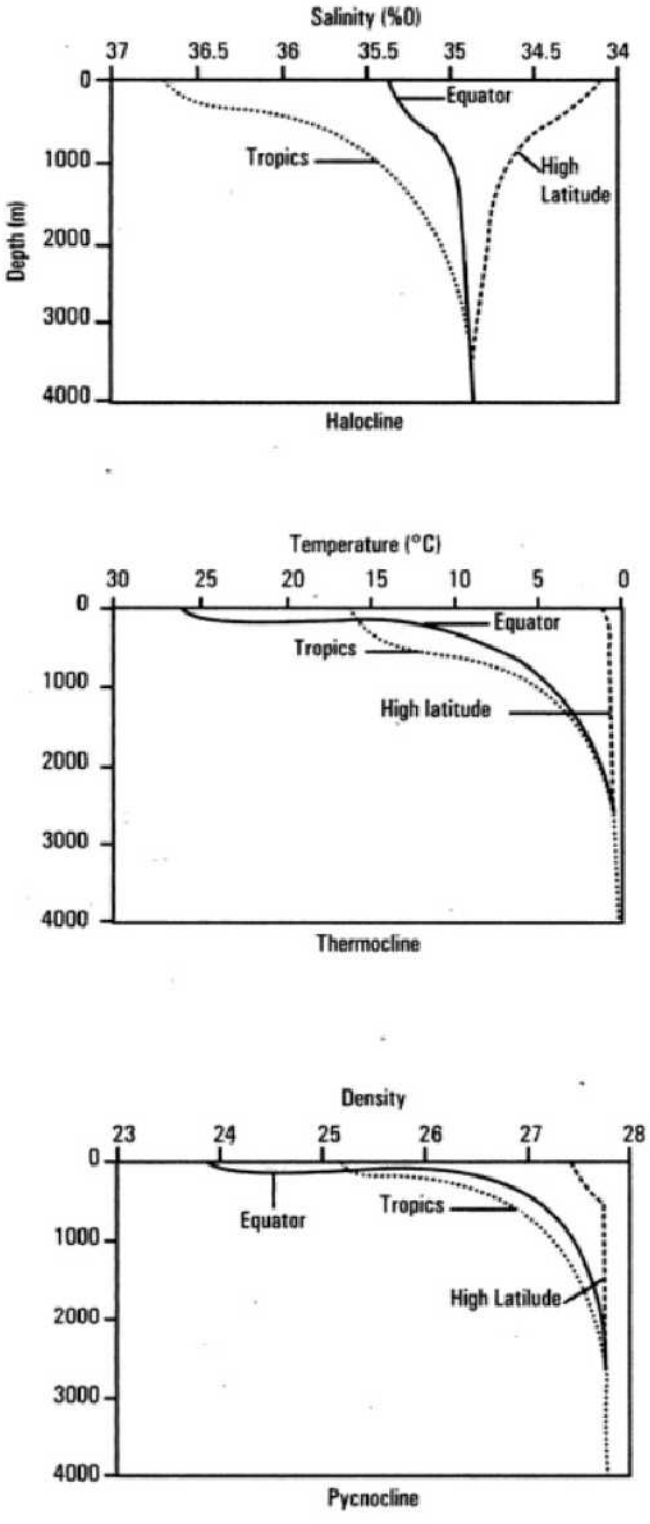

Fig. 4.8 – Halocline, Thermocline and Pycnocline

transported to the ocean by running water and wind, etc.

(ii) Volcanic Deposits: Ash, pumice, cinder, etc.

(iii) Biotic Deposits: Neretic deposits, pelagic deposits (ooze), globigerenia ooze, radiolarian ooze, red clay, etc. These deposits consist material mainly of marine organic origin, i.e. shells, skeletons of marine animals and plants. The most common of the biogenous sediments are calcareous ooze and siliceous ooze.

(iv) Cosmogenous Deposits: Dust, tektites and particles.

The general pattern of sediments on the ocean floor has been shown in **Fig. 4.9**.

Ocean Currents

Surface ocean currents are driven by the prevailing winds and by the spinning motion of the Earth which drives the currents into circulating whirlpools, or gyres. Deep sea currents, over 100 m below the surface, are driven by differences in water temperature and salinity, which have an impact on the density of deep water and on its movement.
The main causes of ocean currents are:

1. Differential heating of the equatorial and polar oceans.
2. Trade and anti-trade winds.
3. Coriolis effect.
4. Variations in the salinity and temperature of the oceans.
4. Configuration of the coast line and ocean floor.

In general , warm ocean currents bring warm water from the equatorial regions to polar regions and cold ocean currents bring cold water from the polar regions to the equatorial regions. The major ocean currents have been shown in **Fig. 4.10**.

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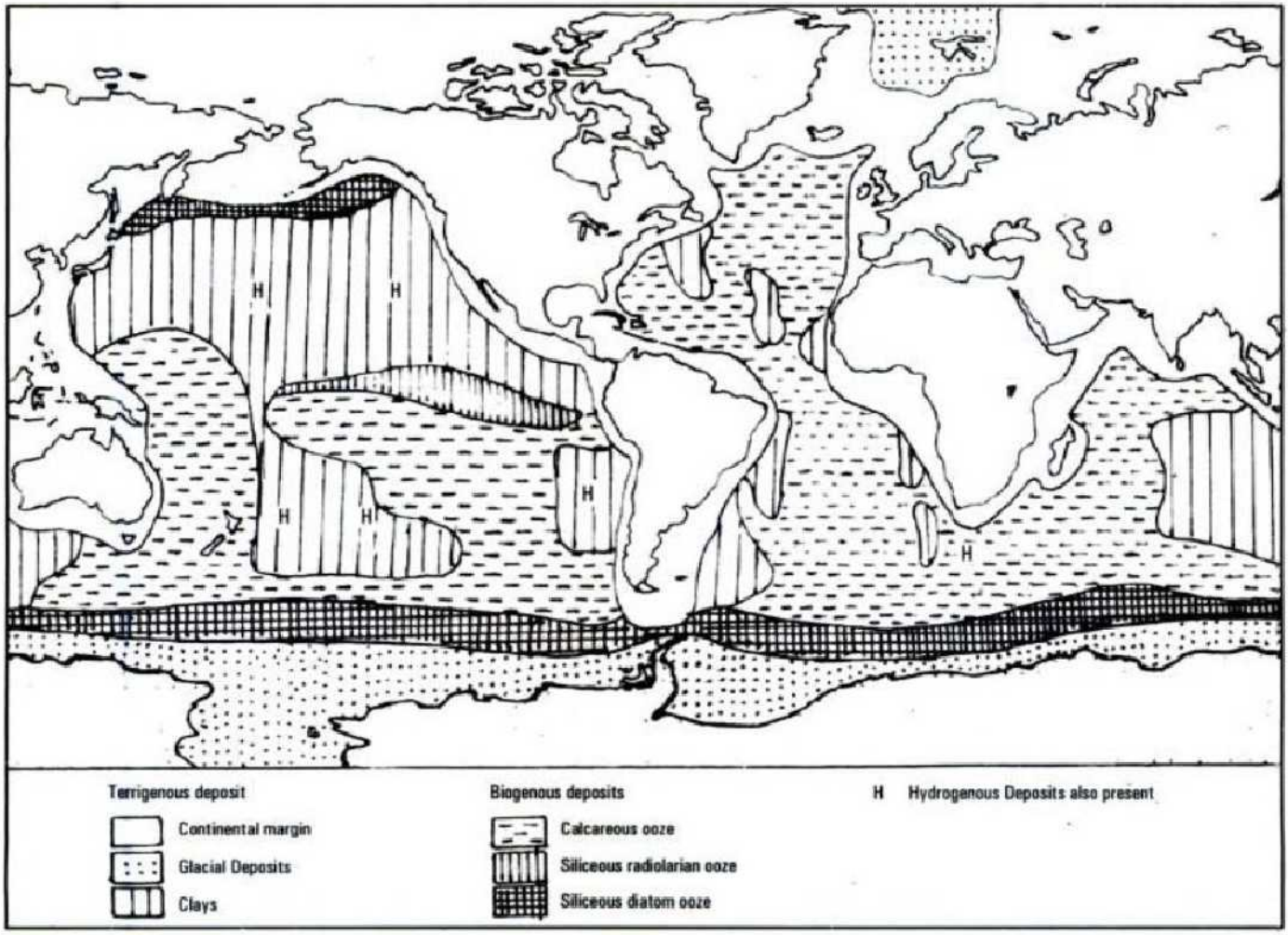

Fig. 4.9 – Ocean deposits

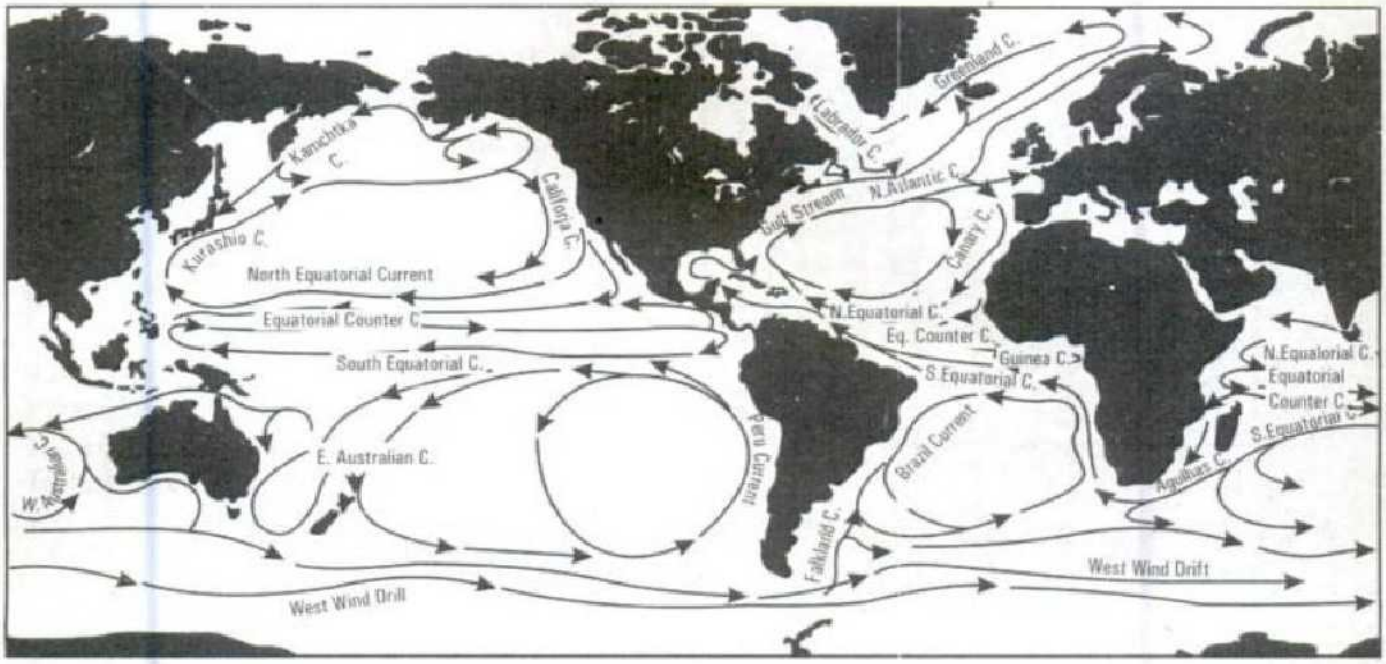

Fig. 4.10 – Major surface ocean currents of the world

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Table 4.2: Major Ocean Currents of the World

Ocean	Name of the current	Nature	Effect
North Atlantic Ocean	North Equatorial Current	Warm	Carries the warm water of the Gulf of Guinea towards South America.
	Antilles	Warm	Keeps the temperature of Antilles above 25°C throughout the year.
	Gulf Stream	Warm	Its confluence with the Labrador current produces heavy fog along the coasts of New Foundland. It is one of the important fishing grounds of the world.
	North Atlantic Drift	Warm	It keeps the ports of Norwegian Sea and Barents Sea like Murmansk and Severodvinsk (Russia) situated at higher latitudes ice-free throughout the year.
	Labrador	Cold	The confluence of Labrador and Gulf Stream produces heavy fog in the region of New Foundland which create conducive conditions for fishing. The fog creates obstacles in navigation.
	Canaries	Cold	Leads to fog along the western coast of North Africa. Helped in the genesis of Sahara Desert.
South Atlantic Ocean	South Equatorial Current	Warm	Carries warm water from the Gulf of Guinea towards Brazil.
	Brazilian Current	Warm	Keeps the eastern coast of South America warm.
	Benguela Current	Cold	Leads to foggy conditions along the coast of Namibia. Helped in the development of Namibian and Kalahari deserts.
North Pacific Ocean	North Equatorial Current	Warm	Carries heat from the eastern Pacific towards the East Indies. Carries warm water towards Alaska.
	Oyashio/Kurile Current	Cold	The confluence of Oyashio with Kuroshio produces heavy fog around Hokkaido. This confluence is conducive for the development of fisheries.
	Alaska Current	Warm	Keeps the seaports of Alaska open throughout the year.

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	California Current	Cold	Leads to foggy conditions along the coast of California. It helped in the development of Arizona and Sonara deserts.
South Pacific Ocean	South Equatorial Current	Warm	Carries warm water from the eastern parts of the South Pacific towards New Guinea and eastern Australia.
	East Australian Current	Warm	Carries heat from the equatorial region towards the eastern coast of Australia.
	Peru/Humboldt Current	Cold	Helped in the desertification of the Atacama Desert. El-Nino effects the weather in western South America. It also affects the timely arrival of Indian Monsoon.
Indian Ocean	Mozambique Current	Warm	Carries heat from the equatorial region towards the eastern coast of Mozambique.
	Agulhas	Warm	Increases temperature along the eastern coast of South Africa.
	West Australian Current	Cold	Leads to foggy conditions along the western coast of Australia. It helped in the genesis of West Australian Desert.

Sea-waves

It is a ridge of water between two depressions. A wave approach, they curl into an arc and break. The energy of surface waves is responsible for the erosion of the coast. Waves also initiate currents which run along the coast and which are the moving force in long-shore drift. The height of a wave is generally proportional to the square of wind velocity.

Tides

The periodic short-term rise and fall in the sea levels is known as tide. It is produced due to gravitational interaction of Earth, Moon and Sun. Moon exerts the strongest influence on tides because of its closeness to the Earth.

Spring Tides

On the full moon and the new moon, the tides occur are the highest and known as the *Spring Tides*, while in the Ist and 3rd quarters of a month, tides are lower than the usual, which is known as the *Neap Tides* **(Fig. 4.11).**

The highest tides in the world occur in the *Bay of Funday*. The highest tides in India are recorded at *Okha*, Gujarat.

It takes 24 hours 50 minutes for the rotating Earth to bring the same meridian vertically below the Moon everyday. Hence, tides occur at regular intervals of 12 hours and 25 minutes. Generally, tides occur twice a day.

Merits of Tides

Tides generally help in making some of the rivers navigable for ocean going ships. For example, London and Kolkata have become important ports owing to tidal nature of the mouths of Thames and Hooghly, respectively.

Tides also wash out the sediments brought by rivers and thus, retard the formation of deltas and help in cleaning the coastal regions.

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The tidal force may also be used as a source for the generation of electricity. The generation of tidal energy was started by France, followed by Japan. India produces tidal energy in the Gulf of Khambat and Kachchh.

Coral Reefs

Coral reef is a linear mass of calcium carbonate (aragonite and calcite) assembled from coral organism, algae, mollusks, worms, etc. Coral may contribute less than half of the reef material. In most reefs, the predominant organisms are stony corals that secrete calcium carbonate (limestone). The coral reefs are also referred as the *'Rainforests of the oceans'* because of their tremendous biodiversity.

The coral reefs may be broadly classified in the following categories:

(i) Fringing Reef: Reef that is directly attached to a shore or borders it with an intervening shallow channel or lagoon.

(ii) Barrier Reef: Reef separated from a mainland or island shore by a deep lagoon. The Great Barrier Reef lying to the east of Queensland is the largest living structure on the Earth. It extends for more than 2000 km.

(iii) Atoll Reef: A more or less circular or continuous barrier reef extending all the way around a lagoon without a central island.

Distribution of Coral Reefs in the World : Most of the coral reefs are found between 30° N and 30° S, where the average temperature of the sea surface is about 21°C.

According to one estimate coral reefs cover about 284,300 square kilometers, with the Indo-Pacific region (including the Red Sea, Indian Ocean, South East Asia and the Pacific) accounting for 92% of the total coral formations. The Caribbean coral reefs account for about 7.5% of the total coral formations of the world **(Fig. 4.12)**.

Coral reefs are almost absent from along the west coast of Americas and the west coast of Africa. Corals are also restricted from the coastline of South Asia from Pakistan to Bangladesh. They are also not found in the delta region of the Ganga-Brahmaputra river and the Amazon river due to the addition of vast quantities of fresh water.

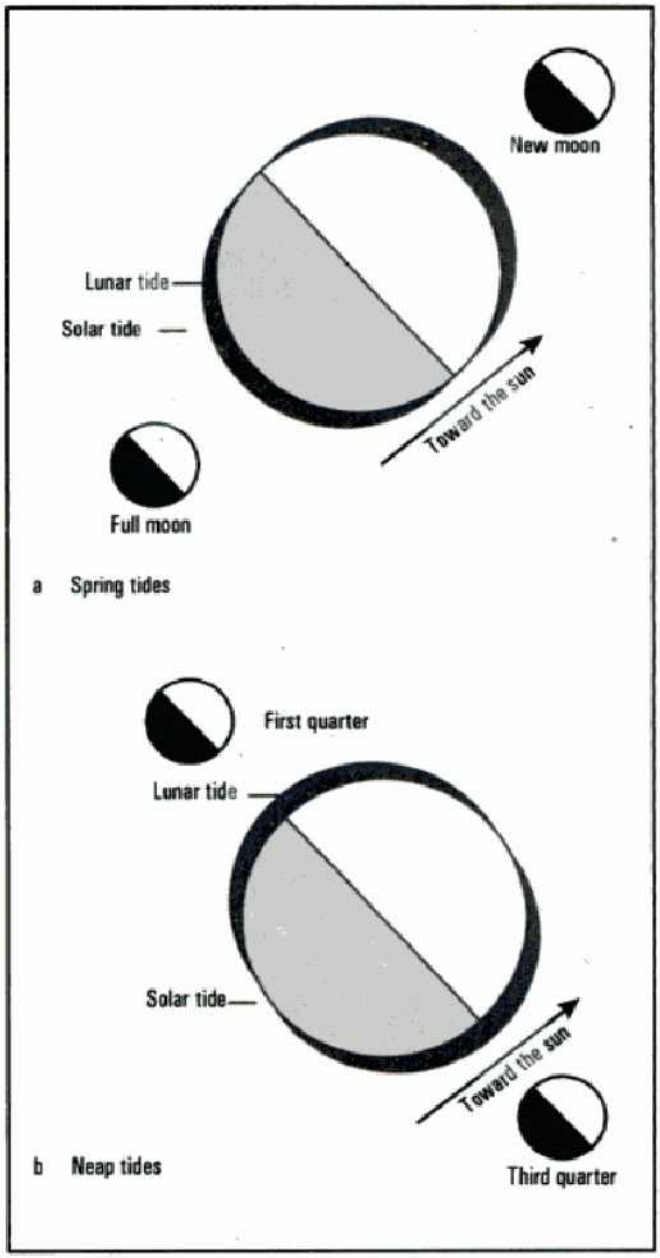

Fig. 4.11 – Relative positions of the Sun, Moon, and Earth during spring and neap tides

Tsunami

The seismic waves, travelling through the ocean and sea water, result into high sea waves which are known as tsunamis. *'Tsunamis'* is a Japanese word which has been universally

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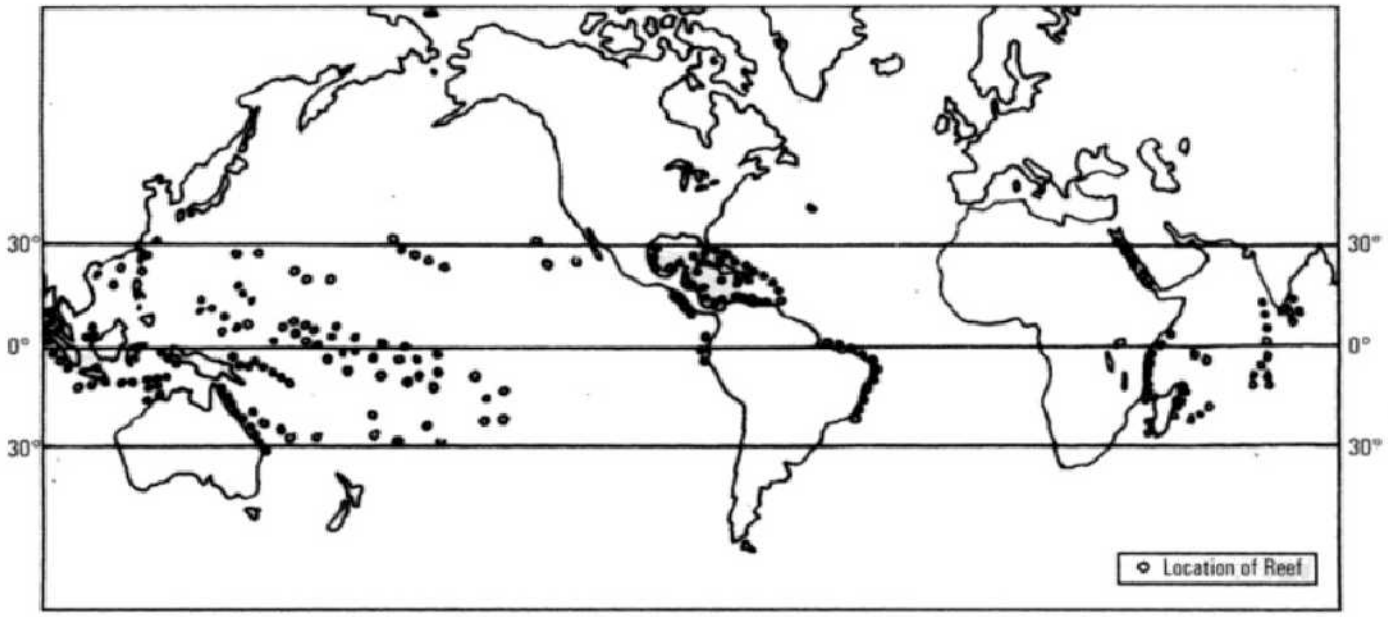

Fig. 4.12 – Distribution of coral reefs

adopted to describe the seismic sea waves. These waves are capable of causing considerable destruction in certain coastal areas, especially where submarine earthquakes occur. Once a tsunami is generated, its steepness (ratio of height to length) is extremely low. This lack of steepness, combined with wave's very long period (5 to 6 minutes), enables it to pass unnoticed beneath ship at sea. As the seismic sea wave approaches shore, the situation changes rapidly and often dramatically. While the period of the wave remains constant, velocity drops, and wave height greatly increases. As the crest arrives at coast, the water surges ashore in the manner of a very high, fast tide. In the vicinity of the epicenter of the earthquake, the tsunami waves can reach a height of over 30 metres (100 feet). The tsunami travels at a speed of 100 to 150 km per hour which may pick up to 650 to 950 km per hour. Likewise, it may travel considerable distance.

The tsunamis occur in or around the oceanic trenches. They are more frequent in the Pacific ocean. The other oceans like the Atlantic ocean and the Indian ocean, are, however, not free from the occurrence of seismic waves. On Ist April, 1946, a fracture along the Aleutian Trench, generated a tsunami that quickly engulfed the Scotch-Cap lighthouse in Unimark Island in the Aleutian. Trench The lighthouse was completely destroyed, and five coastguards working in the lighthouse were died.

Some of the greatest tsunamis of the recent past include the Japan tsunami (11th March 2011) which killed more than 25,000 people in and around Sendai city and ravaged the Fukushima nuclear plant. The nuclear radiation alarmed the population of Japan, China, North and South Koreas and as far as U.S.A. and Canada. Banda Aceh (Sumatra) seismic wave which occurred on 26th December, 2004 in the Sunda Trench and killed over two lakh people in the neighbouring countries. The impact of the tsunami was quite serious in Andaman and Nicobar Islands and the Tamil Nadu coast of India. Coastal areas of the distant countries like Sri Lanka, Maldives, Oman, and Somalia were also adversely affected resulting into human casualties and loss to property.

In 1703, at Awa (Japan) one lakh people died because of seismic waves of serious magnitude. On 27th August, 1883, the explosive volcanic eruption of Krakatoa in Indonesia generated 35 Meter high waves that destroyed 163 villages and killed more than 36,000 people. The Lisbon city of Portugal was inundated by tsunami (over 15 metres in height) in the earthquake of 1755 in which over 60,000 people were killed.

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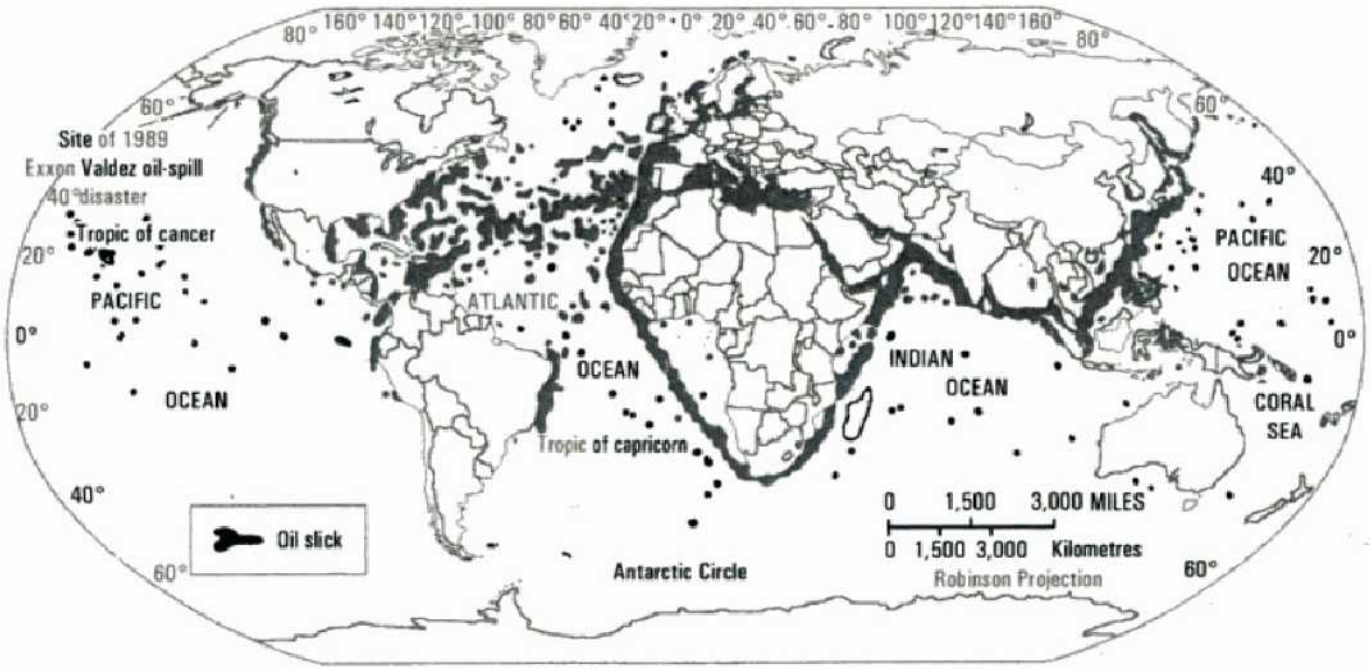

Fig. 4.13 – Location of recent visible oil slicks worldwide. The location of the 1989 Exxon Valdez oil spill is noted on the map.[Data from Organisation for Economic Cooperation and Development, The State of the Environment.Paris:Organisation for Economic Cooperation and Development, 1985.] After Christopherson, R.W. Elemental Geosystem, 1995, p.533.

Since 1948, an International Tsunami Warning Network has been in operation around the Pacific Ocean to alert the residents to possible danger. Its headquarters is at Honolulu. Much success has, however, not been achieved as the occurrence of earthquakes is sudden and the speed of the tsunami may be around one thousand km per hour. Tsunamis are thus a great natural hazard.

Marine (Ocean) Pollution

With the increasing pressure of population and international trade, the sea-routes have become crowded. The excessive utilisation of ocean resources can result in the accidental (or unintentional) release of harmful substances. The marine pollution change the quality of the water or affect the physical and biological environment. The major causes of marine pollution are (i) volcanic eruption, (ii) oil-pollution–natural seeps, offshore-drilling, near shore refining, and accidents of tankers, (iv) spill of refined oil (v) dumping of wastes, etc.

The seriously polluted tracts of the oceans have been shown in **Fig.4.13.** It may be seen from this figure that the international sea-routes are seriously polluted. Out of all the oceans, the North Atlantic Ocean, Arabian Sea, Red Sea, Mediterranean Sea, North Sea, Baltic Sea, Strait of Malacca, China Sea are the most polluted regions of the world.

Environmental Change

Environmental change is a continuous process that has been in operation since the Earth came into existence about 4600 million years ago. Earlier, there was a belief that man is the product of the Earth (Miss Semple), but now human beings are affecting the environment significantly.

At present the oil spill in the oceans and nuclear ration (Fukushima) are causing great damage to the ecosystems. The location of recent visible oil slicks worldwide have been shown in **(Fig. 4.13).**

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Chapter Five

Biogeography

Chapter Concepts

- Biosphere
- Ecosystems of the Earth
- Soil System

The biosphere can be defined as the part of Earth where life exits. It includes the forests, grasslands, and familiar animals of land together with the numerous creatures that inhibit the sea and atmosphere. Biosphere consists of 1.5 million described species and perhaps as many as 3 million not yet described. Each species lives within its own limited environmental setting.

Biosphere (Ecosphere)

The intricate, interconnected web that links all organisms with their physical environment is the biosphere. Sometimes called *Ecosphere*, the biosphere is the area in which physical and chemical factors form the context of life. The biosphere exists in the overlap among abiotic sphere, extending from the seafloor to about 8 km (5 miles) into the atmosphere. Life is sustainable within these natural limits. In turn, life processes have powerfully shaped the other three spheres through various interactive processes. The biosphere has evolved, reorganised itself at times, faced extinction, gained new vitality, and managed to flourish overall. Earth's biosphere is the only one known in the solar system in which life exists.

Components of Biosphere

The abiotic or inorganic component of the biosphere represents physical environment of the whole biosphere or part thereof. For example, light, temperature, water, air, climate, rocks, etc are the abiotic components of the biosphere. The abiotic of the biosphere includes the lithosphere, the atmosphere and the hydrosphere.

The biotic or organic components of the biosphere consist of three subsystems, e.g. (i) plants, (ii) animals including man, and (iii) the micro-organism.

Ecosystem

Ecosystem is a self-regulating association of living plants, animals, and their non-living physical and chemical environment. The concept of ecosystem was developed by Tansley.

Ecological Succession

The process whereby different and usually more complex assemblages of plants and animals replace older and usually simpler communities is known as ecological succession.

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Ecotone

A boundary transition zone between adjoining ecosystems that may vary in width and represent areas of tension as similar species of plants and animals compete for the resources.

Producer

Organism that are capable of using carbon dioxide as their sole source of carbon, which they chemically fix through photosynthesis to provide their own nourishment. Such organism is also called *autotroph*.

From these producers, which manufacture their own food, energy flows through the system along a circuit called the *food chain*, reaching consumers and eventually decomposers. Ecosystems are generally structured in a food-web, a complex network of interconnected food chains. In a food-web, consumers participate in several different food-chains. Organism that share the same basic foods are said to be at the same trophic (feeding, nutrition) level.

Consumer

Organism in an ecosystem that depends on producers (autotrophs), organism capable of using carbon dioxide as their sole source of carbon for their source of nutrients.

Herbivore

The primary consumer in a food chain, which eats plant material formed by a producer that has synthesized organic molecule.

Carnivores

A carnivore is a secondary consumer eats primary and secondary consumers and is referred to as the '*top carnivore*' in the food chain.

Omnivore

A consumer that feeds on both producers (plants) and consumers (meat) – a role occupied by humans, among other animals.

Decomposer

Microorganism that digest and recycle organic debris and waste in their environment: includes bacteria, fungi, insects, and worms.

Food Chain

The circuit along which energy flows from producers, who manufacture their own food, to consumers; a non-directional flow of chemical energy, ending with decomposer. Basically all animals depend on plants for their food. Foxes may eat rabbits, but rabbits feed on grass. A hawk eats a lizard, the lizard has just eaten a grasshopper, and the grasshopper was feeding on grass blade. Similarly the caterpillar eats the leaf; the blue-tit eats the caterpillar, but may fall prey to the kestrel **(Fig .5.1)**.

Food-web

A complex network of interconnected food chain.

Niche

(French nicher, to nest) refers to the function, or occupation, of a life form within a given community. It is the way an organism obtains and sustain the physical, chemical and biological factors it needs to survive. It is the basic function, or occupation, of a life-form within a given community, the way an organism obtains its food, air and water. In other words, it is the description of an organism's functional role in habitat – its '*job*.' Among the functions, a niche includes (i) a habitat niche, (ii) a trophic (food) niche, and (iii) a reproductive niche.

Ecological Relationship

A study of food-chains and webs is a study of who eats what, and where they do the eating **Fig. 5.2.** Demonstrates the summer time distribution of population in two ecosystems, grassland and temperate forest. The stepped population pyramid is characteristic of summer conditions in such ecosystems. It may be observed from the Fig. 5.2 that there is a decreasing number of organism at each successive higher trophic level. The base of the temperate forest pyramid is narrow, however, because most of the producers are large, highly productive trees and shrubs, which are

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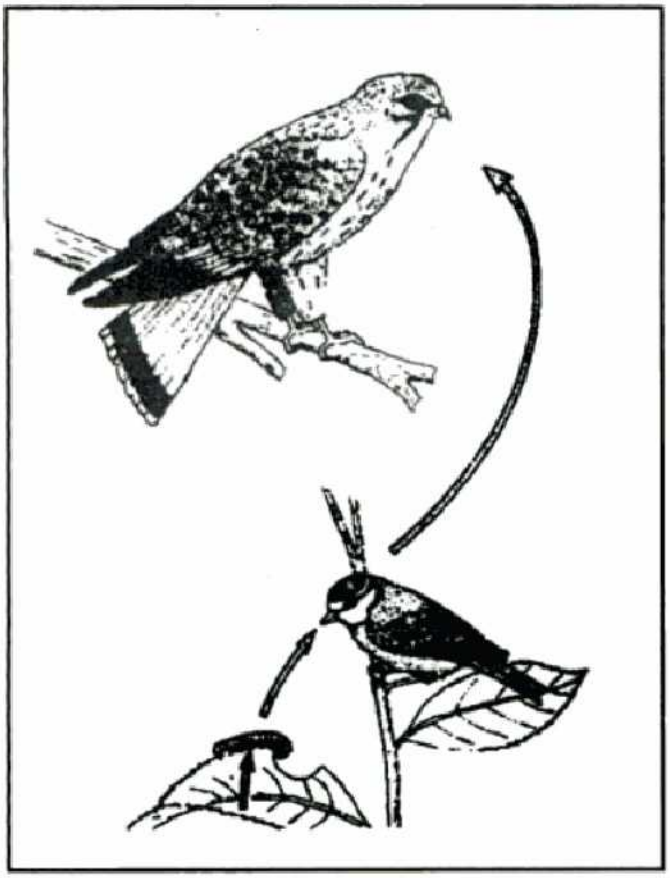

Fig.5.1 – A Food Chain: The caterpillar eats the leaf; the blue-tit eats the caterpillar but may fall prey to the kestrel

outnumbered by the consumers they can support in the chain.

Eutrophication

A natural process in which lakes receive nutrients and sediment and become enriched; the gradual filling and natural aging of water bodies.

Life Zone

An altitudinal zonation of plants and animals that form distinctive communities. Each life zone possesses its own temperature and precipitation relationships.

Biomass

Biomass is the net dry weight of organic material; it is biomass that feeds the food chain.

Ecosystems of the Earth

The major ecosystems of the Earth are generally divided into: (i) aquatic, and (ii) terrestrial.

(i) Aquatic Ecosystem : An association of plants and animals and their non-living environment in water-setting is known as aquatic ecosystem. The oceans, lakes, estuaries, deltas and freshwater bodies are the examples of aquatic ecosystem.

(ii) Terrestrial Ecosystem : A self-regulating association characterised by specific plant formations; usually named for the predominant vegetation and known as biome when large and stable.

The Major Terrestrial Biomes

Biome is a large terrestrial ecosystem characterised by specific plant communities and formations; usually named after the predominant vegetation in the region. Following are the major terrestrial biomes:

1. Equatorial and Tropical Rain Forest (ETR): This biome is found on both sides of the equator. It is characterised with hot and humid climate. The climate of the equatorial biome is characterised by day-length (12hours), high insolation, and the average annual temperature around 25°C, and the average annual rainfall is about 200 cm.

The Amazon region is the largest tract of equatorial and tropical rain forest, also called the *selva*. Rain forests are also found in the Congo Basin, Madagascar (Africa), South East Asia (Indonesia, Malaysia, Thailand, etc.), Colombia, Ecuador and western Venezuela. Rain forests represent approximately one-half of Earth's remaining forests, occupying about 7% of the total land area worldwide **(Fig. 5.3)**.

The equatorial rain forests are characterised with Lianas (vines) stretch from tree to tree, entwining them with cords that can reach 20 cm in diameter. Epiphytes flourish there too; such plants as orchids, bromeliads, and ferns that live entirely above the ground, supported physically but not nutritionally by the structure of other plants.

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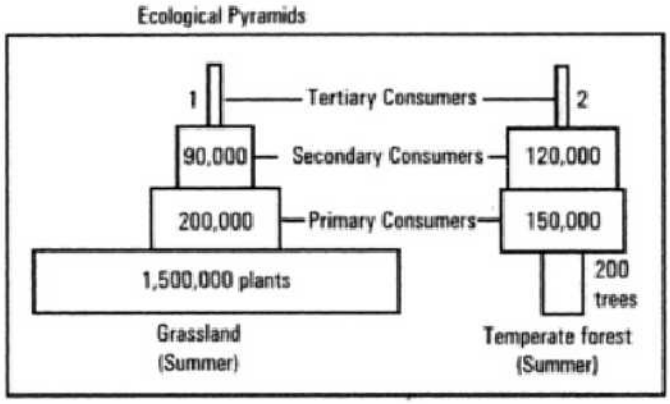

Fig.5.2 – Ecological pyramids for 0.1 hectare (0.25 acres) of grassland and forest in the summers are shown

Source: Fundamentals of Ecology by E. P. Odum, 1971

The rain forest canopy form three levels. The upper level is not continuous, but features tall trees whose high crowns rise above the middle canopy. The middle canopy is the most continuous, with its broad leaves blocking much of the light and creating darkened forest floor. The lower level is composed of seedlings, ferns, bamboo, etc.

The trees have smooth, slender trunks, covered with thin bark and buttressed by large wall-like flanks that grow out from the trees to brace the trunk. There are usually no branches for at least the lower two-thirds of the tree trunks.

The wood of many rain forest trees is extremely hard, heavy, and dense – in fact, some species will not even float. Exceptions are *balsa* and a few others, which are very light. The main varieties include mahogany, ebony, and rosewood. Logging is difficult because individual species are widely scattered; a species may occur only once or twice per square kilometre.

The insect and animal life of the rain forest is diverse, ranging from small decomposers (bacteria) to many animals living exclusively in the upper stories of the trees. These tree dwellers are known as arboreal. They include monkeys, lemurs, sloths, parrots, and snakes. Beautiful birds of many colours, tree frogs, lizards, bats, and rich insect life that include over 500 species of butterflies are found in rain forests.

More than one-half of Earth's original rain forest is gone, cleared for timber, fuel, pastures and farming. Unfortunately, the dominant trees require from 100 to 250 years to establish themselves after major disturbance.

2.Tropical Seasonal Forest and Scurb (TrSF): This biome occupies the regions of low and erratic rainfall. The trees of this region are deciduous and semi-deciduous. The semi-deciduous trees lose their leaves during the dry season. The rainfall in this biome is confined to about 90 days. In fact, it is the biome found in the monsoon climate. The monsoonal forest average 15 m high with no continuous canopy of leaves. This biome stretches into North-East India, Indonesia, Malaysia, Myanmar, Philippines, Thailand, Brazil, Zambia, and Tanzania **(Fig. 5.3).** The main trees are *sal, sagon* (teak), *shisum*, gum-trees like carnauba and palm-hard waxes.

Local names are given to these communities: the *caatinga* of Bahia State of North-East Brazil, the *chaco* area of Paraguay and North Argentina, the *brigalow scrub* of Australia, and *dornveld* of South Africa.

3.Tropical Savanna: The savanna biome consists of a combination of trees and grassland in various proportions. This is a transitional biome between the tropical forests and semi-arid tropical steppes, and deserts. The savanna biome also includes treeless tracts of grasslands. The trees of savanna woodlands are characteristically flat topped. Savannas covered more than 40% of the Earth's land surface before human intervention but were especially modified by human-caused fire. Fires occur annually throughout the biome. Elephant grasses averaging 5 m high are found in this biome. This biome is much richer in humus than the wetter tropics and are better drained, thereby providing a better base for agriculture. Sorghums (millets), wheat, and

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groundnut (peanuts) are common crops grown in this biome.

Savanna shrubs and trees are frequently *xerophytic*, or drought resistant, with various adaptations to protect them from the dryness. They are characterised by small thick leaves, rough bark, or waxy leaf surfaces.

Africa has the largest region of this biome, including the famous Serengeti Plains and the Sahel region. It is also found in parts of Australia, India, and South America **(Fig. 5.3)**. Some of the local names for these lands include the *Llanos* in Venezuela, *Campo Cerrado* in Brazil and Guiana, and the *Pantanal* of south western Brazil. The main animals of the savanna grassland are lions, cheetah (tigers), zebra, giraffe, buffalo, gazelle, wildebeast, antelope, rhinoceros, and elephant.

4.Hot Deserts and Semi-deserts: The desert biome includes several formation classes that are transitional from savanna biomes into vegetation of the arid desert. It consist of the semi-desert and hot desert regions.

The semi-desert is a transitional biome found in a wide latitude range from the tropical zone to the mid-latitude zone. Semi-desert consists of sparse xerophytic shrubs. One example is the sage brush vegetation of the Colorado Plateau (USA) and Cactus plants **(Fig. 5.3)**.

The dry deserts stretch mainly in the hot deserts of the world. The main vegetation consist of small, hard-leaved, or spiny shrubs, succulent plants (such as cactus), or hard grasses. The typical desert vegetation include saguaro cactus, the prickly pear cactus, the ocotillo, creosote bush, and smoke tree.

5. Cold Deserts and Semi-deserts: The cold deserts and semi-desert biomes are found in the higher latitudes. This biome stretches over Sierra Nevada (USA), Ladakh (India), and Andes (Argentina). Winter snow occurs in the cold deserts, but are generally light. Summers are hot. The dryness, clear skies, and sparse vegetation lead to high radiative heat loss and cool evenings. Many areas of these deserts are

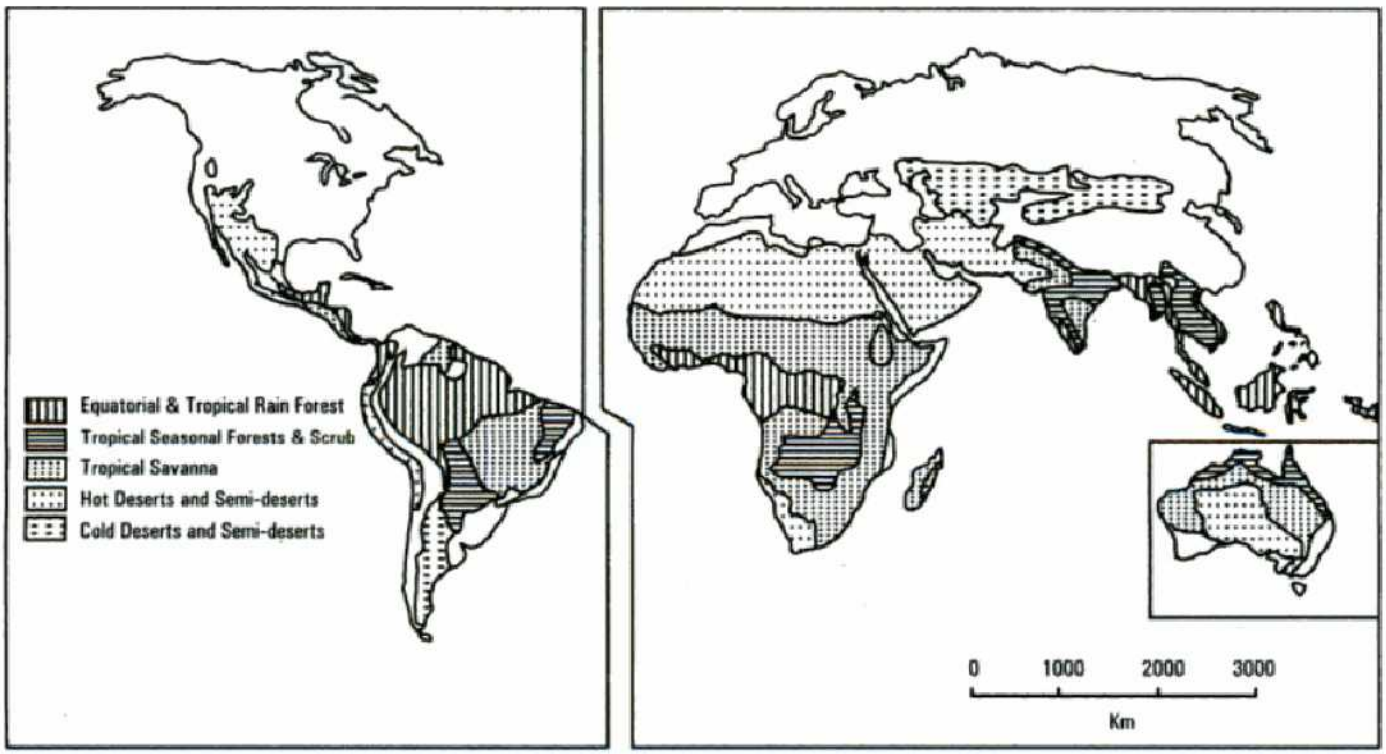

Fig. 5.3 – The major terrestrial biomes of the world (after Christopherson R.W. Geosystems, 1999, Printice-Hall)

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covered with sage-brush and scrub vegetation **(Fig.5.3)**.

6. Temperate Rain Forest: The temperate rain forest biome is recognised by its lush green forests at the middle and high latitudes. This biome is mainly confined along narrow margins of the Pacific Northwest in North America **(Fig. 5.4)**.*The tallest trees in the world,* namely, redwood (*sequoia sempervirens*), douglas fir, spruce, cedar, and hemlock occur in this biome. These trees can exceed 1500 years of age and typically range in height from 60 to 90 m with some exceeding 100 m. This biome includes several distinct communities in North America, Europe, and Asia. Some of the other important trees of this biome are deciduous oak, beech, hickory, maple, elm, chestnut, pines, etc **(Fig. 5.4)**.

7. Mid-latitude Broad-leaf Mixed Forests: This biome is found in the moist continental climates of North America, Europe, and Asia **(Fig. 5.4)**. The main trees of this biome are pines, hemlock, with deciduous varieties of oak, beech, hickory, maple, elm, chestnut, etc.

8. Mediterranean Shrubland (MSh): The Mediterranean biome has hot rainless summer and cool-moist winters. The dominant species of trees of this biome are stunted and tough in their ability to withstand hot summer drought. The vegetation is called *sclerophyllous* (from *sclera* or 'hard' and *phyllos* for 'leaf'); it averages a metre or two in height and has deep, well developed roots, leathery leaves, and uneven low branches. In California this vegetation is known as *chaparral*. In the European Mediterranean region it is known as *maquis*. In Chile, such a region is called *mattoral;* in south Australia *mallee* scrub. The cork-oak is also a vegetation of this biome **(Fig. 5.4)**.

9. Mid-latitude Grasslands: This biome includes the *steppes* (Eurasia), *prairie* (USA, Canada), *pampas* (Argentina), *velds* (South Africa), and *downs* in (Australia). This biome is known for nutritious grasses. The grasses flower in spring and early summer **(Fig. 5.4)**.

10. Needleleaf Biome or Boreal Forest: The needleleaf forest biome is also called the boreal forest **(Fig. 5.4)**. A more open form of boreal forest in the arctic and sub-arctic regions is known as *taiga*. In the Southern Hemisphere, this biome is found in the montane regions. The main trees of this biome are pine, spruce, and fir. The Sierra Nevada, Rocky Mountains, Alps, and Himalayas have similar forest communities **(Fig. 5.4)**.

11. Tundra Biome: The tundra region remains snow covered over the greater parts of the year.

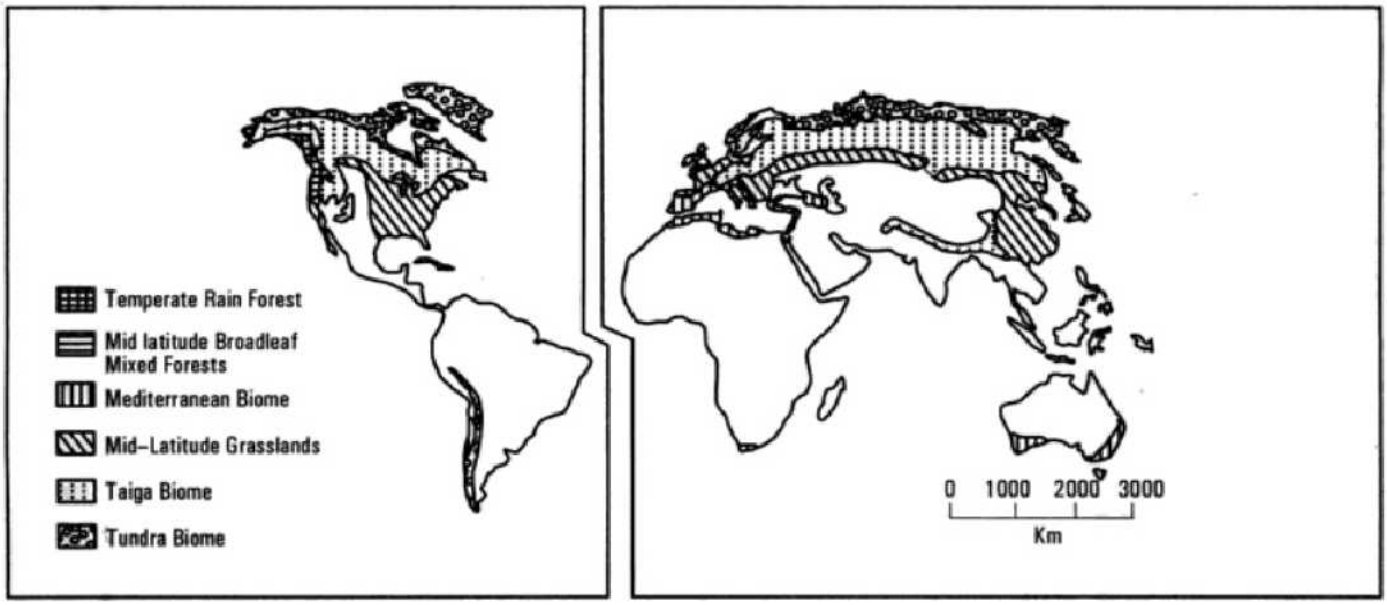

Fig. 5.4 – The major terrestrial biomes of the world (After Christopherson, R.W., Geosystems, 1999, Printice-Hall)

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In this climate plants grow only during the brief summer of long days and short nights. Plants of the tundra biome are mostly low herbs, sedges, cotton grasses, grasses, mosses, and lichen **(Fig. 5.4)**.

Mangrove (Rhizophora) Forests

Low, muddy coasts in tropical and some sub-tropical areas are often home to tangled masses of trees known as mangroves. These large flowering plants are never completely submerged, but because of their intimate association with the ocean they are considered marine plants. They thrive in the sediment rich lagoons, bays, deltas and estuaries of the rivers of South Asia, South-East Asia, tropical Africa, Cameroon, and the tropical Americas. In addition to mangrove, there are salt marshes in the Northern Hemisphere around 30th parallel. In these marshy lands grow the salt tolerant plants known as *halophytic*. The wetland ecosystems are quite fragile and are threatened by human development. In some countries, the salty areas and mangroves have been reclaimed because the conceived fear of disease or pestilence in the swamplands.

Biodiversity

Today, over six hundred billion humans, approximately one million animal species and 355,000 known plant species depend on the air, water and land of the Earth. The location of areas of exceptionally high biological richness–biodiversity hotspots have been shown in **Fig. 5.5**.

It may be observed from **Fig. 5.5** that the Islands of Antilles, Meso-American forests, tropical Andes, Cerrado (Brazil) and the Atlantic forest region have special bio-diversity. The Guinea forests of West Africa, Madagascar, Cape and Western Cape (South Africa), Western Ghats (India), South-East Asia, especially Indonesia, Malyasia, Philippines, etc. have exceptionally high biological diversity.

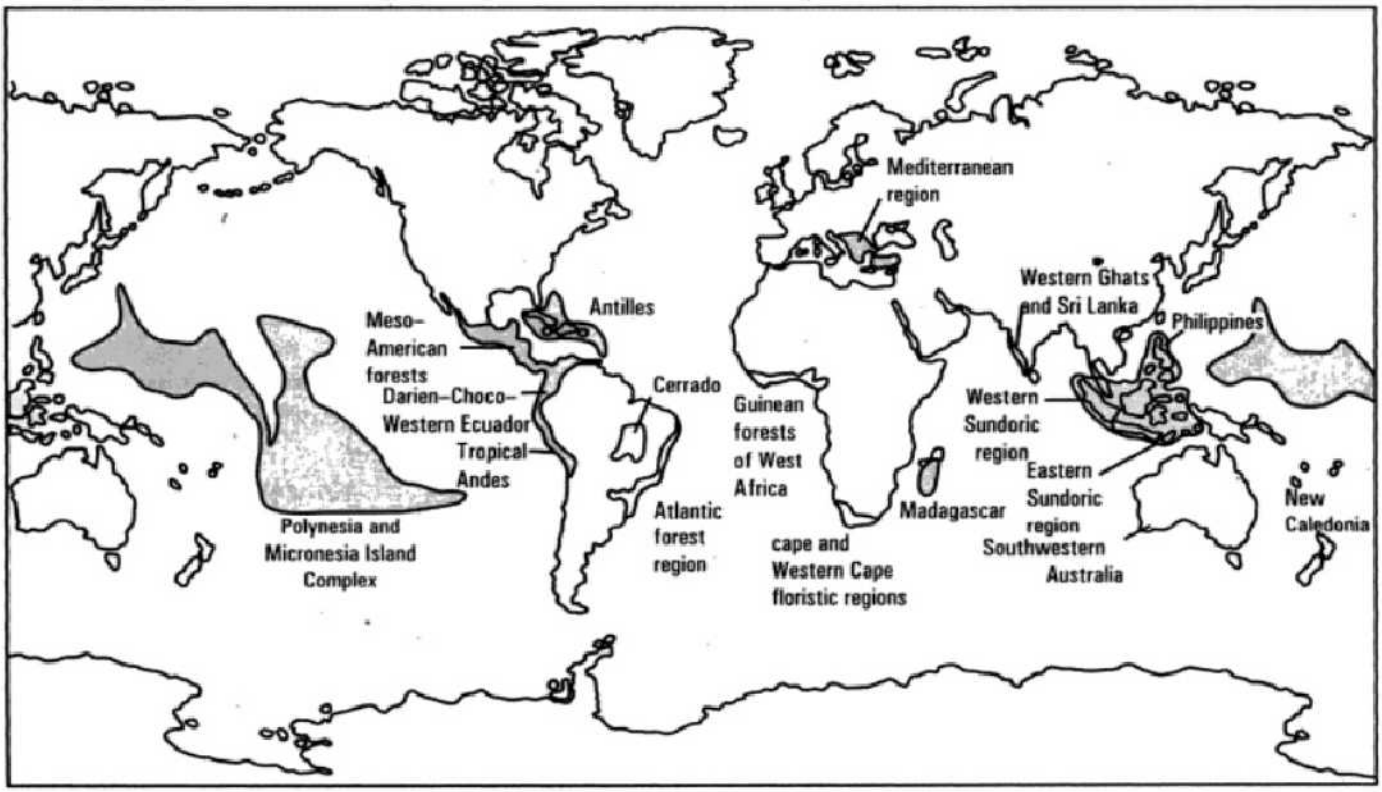

Fig. 5.5. – The location of areas of exceptionally high biological richness–biodiversity hot spots, as determined by Conservation International

Source: C. Barry Cox et. al. 2004, *An Ecological and Evolulionary Approach, 6th ed. London Blackwell Science. p. 25*

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Soil System

A dynamic natural body made up of fine materials covering Earth's surface in which plants grow; composed of both mineral and organic matter (Christopherson).

Components of Soil

A soil is made up of four elements: (i) parent material – inorganic or mineral fraction (derived from the parent material), (ii) organic material (humus), (iii) air, and (iv) water.

Parent Material

The parent material includes both hard, resistant rocks such as granite and slate, and also the less resistant rocks such as recent volcanic lavas and ashes, and most of the sedimentary rocks like limestone and sandstone.

Humus

Humus is the end-product of the breakdown of dead organic material. It is structureless, dark-brown or black jelly found beneath the soil surface. The humus of ordinary soil is black, and is thus responsible for making the soil darker than the subsoil. It plays an important role in maintaining the fertility of the soil.

Soil Horizon

The various layers exposed in a *pedon*; roughly parallel to the surface and identified as O, A, E, B, and C.

Soil Profile or Pedon

A vertical section of soil in which all the soil horizons are shown, is known as soil profile. Most of the soil profiles include three master horizons. Soil profile extends from the surface to the deepest extent of plant roots, or to where regolith or bed-rock is encountered **(Fig. 5.6)**.

Soil Texture

A soil is generally characterised by the size of its particles. A clayey soil may thus be described as fine, a sandy soil as coarse, while a silty soil is intermediate **(Fig. 5.7).** If one handles a moist soil sample of each of these he feels gritty, sticky, and silky. The standard unit for the measurement of soil particles is the millimetres, but a smaller unit is the micron (1micron=0.001 mm), which is applicable, for instance, to the measurement of soil colloids.

Soil Structure

Soil structure refers to the arrangement of soil particles. The way in which sand, silt, clay and humus bond together to form *peds* is known as soil structure. Structure can partially modify the effects of soil texture. The term *ped* describes an individual unit of soil particles; it is tiny natural lump or cluster of particles held together.

Soil Taxonomy

A soil classification system based on observed properties actually seen in the field; published in 1975 by the U.S. Soil Conservation Service.

Soil Fertility

The ability of soil to support plant productivity when it contains organic substance and clay minerals that absorb water and certain elemental ions needed by plants.

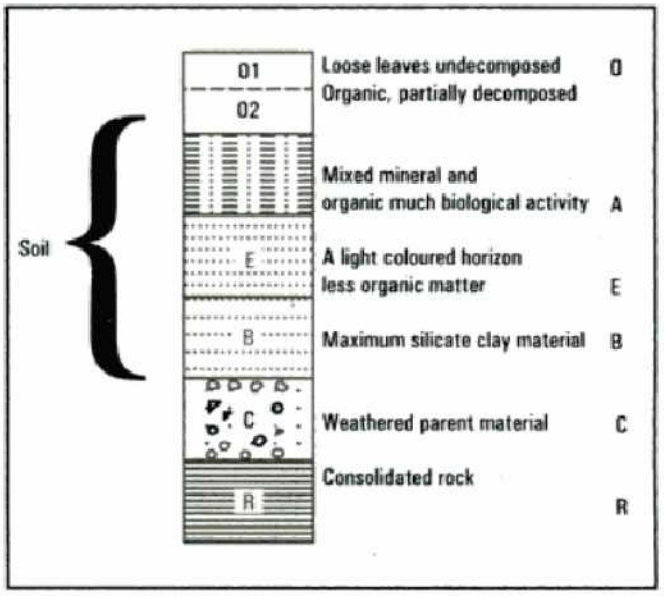

Fig. 5.6 – Soil profile and soil horizons

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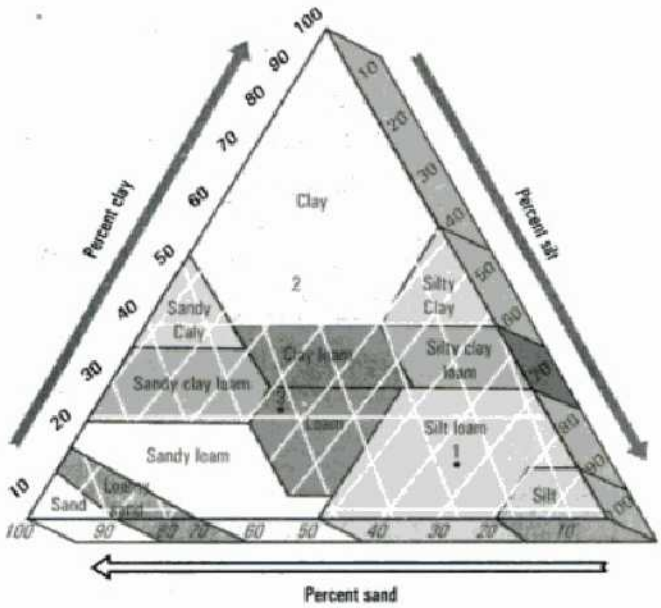

Fig. 5.7 – soil texture triangle. As an example, points 1, 2, and 3 designate samples taken at three different horizons in the Miami silt loam in Indiana. A sample taken near the surface in the A horizon is recorded at point 1; in the B horizon at point 2; and in the C horizon at point 3. Note that silt dominates the surface, clay the B horizon, and sand the C horizon [After USDA Soil Conservation Service, soil Taxonomy, Agricultural Handbook No. 436, Washington, DC: U.S. Government Printing Office 1975]

Major Soil Types

Soils may be divided into (i) zonal, (ii) intrazonal, and (iii) azonal categories.

(i)Zonal Soil: The soil whose characteristics are dominated by the influence of climate and vegetation is known as zonal soil. These soils occur on gently undulating land where drainage is free and where the parent material is of neither extreme texture nor chemical composition.

(ii) Intrazonal: The soil which has been influenced in its development less by climate and vegetation than by other local factors, such as effective drainage, excessive evaporation or parent material (such as limestone), terrain or age is known as intrazonal soil.

(iii) Azonal: The soil which has not been sufficiently subjected to soil-forming processes for the development of a mature profile and so is little changed from the parent rock material is known as azonal soil. Azonal soils do not have B horizon because it is too immature. Thus, A horizon lies immediately above C horizon. Examples are soil forming on sand-dunes, recently deposited alluvium, scree, glacial moraines, marine mud-flats, and volcanic soils.

Soil Taxonomy – Eleven Soil Orders

***Table 5.1:** Soil Taxonomy Soil Orders*

Order	*Marbut Equivalent*	*General Location and Climate*	*World Land Area*	*Description*
Oxisol (ox)	Latosois lateritic soil	Tropical soils, hot humid areas	9.2	Maximum weathering and eluviations, oxic horizon, continuous plinthite layer
Aridisol (arid)	Reddish desert gray desert, sierozem	Desert soils, hot dry areas	19.2	Limited alteration of parent material low climate activity, light colour.
Mollisols (modify)	Chestnut, chernozem	Grassland soils subhumid,	9.0	Noticeably dark with organic material,

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		semi-arid lands		base saturation high, surface with well structured horizons
Alfisols (alfafa)	Gray brown podzolic, degraded chernozem	Moderately weathered forest soils, humid temperate forests	14.7	B horizon high in clays, moderate to high degree of base saturation
Ultisols (ultimate)	Red yellow pozolic, reddish yellow lateritic	Highly weathered forest soils, subtropical forests	8.5	Similar to Alfisols B horizon high in clays, generally low amount of base saturation
Spodosols (odd)	Podzols brown podzolic	Northern conifer forest soils, cool humid forests	5.4	Strongly acidic, coarse texture
Entisols (recent)	Azonal soils, tundra	Recent soil profile, undeveloped, all climates	12.5	Limited development young soils lacking horizons
Inceptisols (inception)	Sub-arctic brown forest lithisols	Weakly developed soils, humid regions	15.8	Intermediate development
Vertisols) (invert	Tropical black clays	Subtropics, sufficient dry period	2.1	Forms large cracks on drying, self mixing action
Histosols (histology)	Peat, bog, muck	Organic soils, wet places	0.8	Peat or bog, organic matter over 20% with clay, no horizon
Andisols (andesite)	-	Areas affected by frequent volcanic activity	Less than 1%	Volcanic parent material

***Source**: Christopherson, R.W., 1995,* **Geosystems**, *New Jersey, Prentice Hall, p.464.*

Soil Erosion

Soil is the most valuable asset to humanity. Its use and misuse resulted into serious problems of soil erosion. At present, soil erosion is a worldwide phenomenon.

Approximately 1.2 billion hectares of the Earth's soil suffer some degree of degradation through erosion caused by human misuse and abuse. The areas of serious concern lie in Asia, Africa, Europe, Australia, North America and South Americas **(Fig. 5.8)**. According to one estimate, 75,000 million tones of productive soil is eroded annually. In India, the problem of soil erosion is quite serious as annually about 6000 million tonnes of soil is being eroded.

Soil erosion not only affects the areas from which soil is removed, but also affects the environment where it is deposited. Such deposits, if takes place in lakes and ponds, destroy the aquatic ecosystems by adding more nutrients, notably nitrogen and phosphorous. It is therefore, imperative to adopt remedial measures to combat soil erosion and to protect the neighbouring ecosystems.

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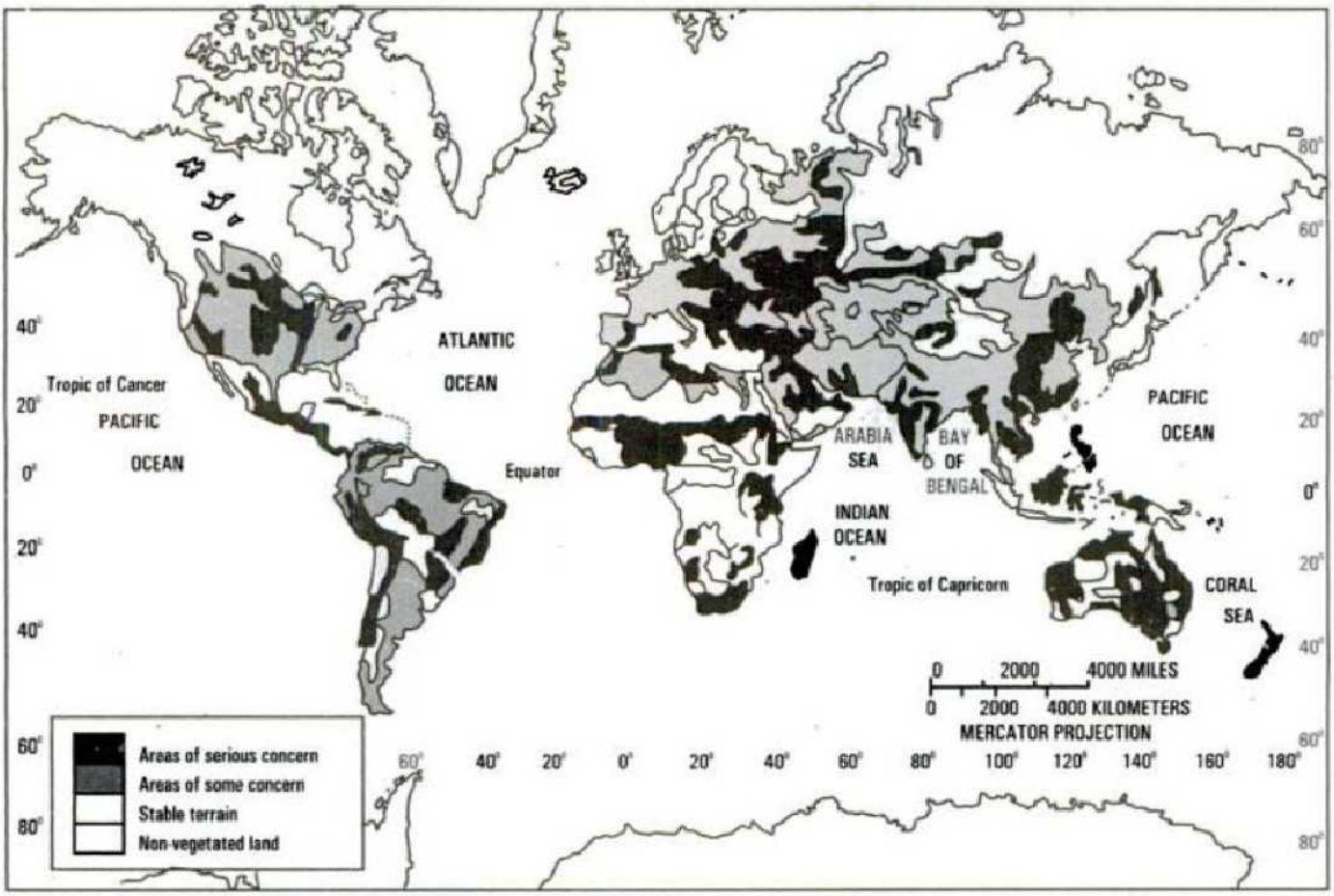

Fig. 5.8 – Approximately 1.2 billion hectares (3.0 billion acres) of Earth's soils suffer some degree of degradation through erosion caused by human misuse and abuse. [A Global Assessment of Soil Degradation, adapted from United Nations Environment Programme, International Soil Reference and Information Centre, "Map of Status of Human-induced Soil Degradation," Sheet 2, Nairobi, Kenya, 1990.]

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Chapter Six •

Facts about the World/Continents/Countries

Chapter Concepts

- Age and Dimensions of Earth
- Large Islands of the World
- North America
- Ocean Trenches
- Major Lakes
- Waterfalls
- Africa

Age and Dimensions of Earth

Age: 4.6 billion years (4.6×10^9)

Mass: 6.6 sextillion tons (6 sextillion metric tons)

Diameter: 12,756.32 kilometres

Circumference:

Equatorial: 40,075.16 kilometres

Polar: 40,008.00 kilometres

Equatorial diameter: 12,756.8 km

Polar diameter: 12,713.8 km

Table 6.1: *Composition of the Earth and the Moon*

	Earth	*Moon*
Iron	34.6	9.3
Oxygen	29.5	42.0
Silicon	15.2	19.6
Magnesium	12.7	18.7
Carbon	1.1	4.3
Aluminium	1.1	4.2
Nickle	2.4	0.6
Sodium	0.6	0.07
Sulphur	1.9	0.3

Source: **Oxford Student Atlas**, 2004, Oxford University Press.

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Table 6.2: *Ocean Areas and Maximum Depths*

Ocean	*Area in sq. km.*	*Maximum depth in metres*
Pacific Ocean	155,557,000	11,022
Atlantic Ocean	76,762,000	8605
Indian Ocean	68,556,000	7258
Antarctic (Southern)Ocean	20,327,000	7235
Arctic Ocean	14,056,000	4665

Source: The **Nystrom Desk Atlas**, 2008, Jones Education Division.

Table 6.3: *World– Land Area and Population–Continentwise.*

Continent	*Land area in sq.km.*	*World land area %*	*Population*	*World population %*
1. Asia	44,009,000	29.4	3,957,700,000	60.6
2. Africa	30,251,000	20.2	915,700,000	14.0
3. North America	24,211,000	16.2	518,300,000	7.9
4. South America	17,832,000	11.9	375,700,000	5.8
5. Antarctica	14,000,000	9.3	-	-
6. Europe	10,445,000	7.0	727,700,000	11.2
7. Australia	8,985,000	6.0	33,100,000	0.5

Source: **The Nystrom Desk Atlas**, *2008, Nystrom Herff Jones Education Division,*

Table 6.4: *Continent-wise Area and Population*

Continent	*Land area in sq. mt.*	*Sq. km.*	*World land area %*	*Total population*	*World population %*
Africa	11,680,000	30,251,000	20.2	915,700,000	14.0
Antarctica	5,400,000	14,000,000	9.3	0	0.0
Asia	16,992,000	44,009,000	29.4	3,957,700,000	60.6
Australia and Oceania	3,469,000	8,985,000	6.0	33,100,000	0.5
Europe	4,033,000	10,445,000	7.0	727,700,000	11.2
North America	9,348,000	24,211,000	16.2	518,300,000	7.9
South America	6,885,000	17,832,000	11.9	375,700,000	5.8

Source: **The Nystrom Desk Atlas**, *2008.* Herff Jones Education Division.

1. Africa

Africa located mainly within the tropics is the second largest continent in area after Asia. The great explorers David Livingstone and H.M. Stanley were the first to explore the interior of Africa, who declared it as *"The Dark Continent"*. It has 53 countries – more than any other continent on the Earth. Africa is a land of many cultures and the home of hundreds of ethnic groups. The people of Africa speak more than 1000 languages.

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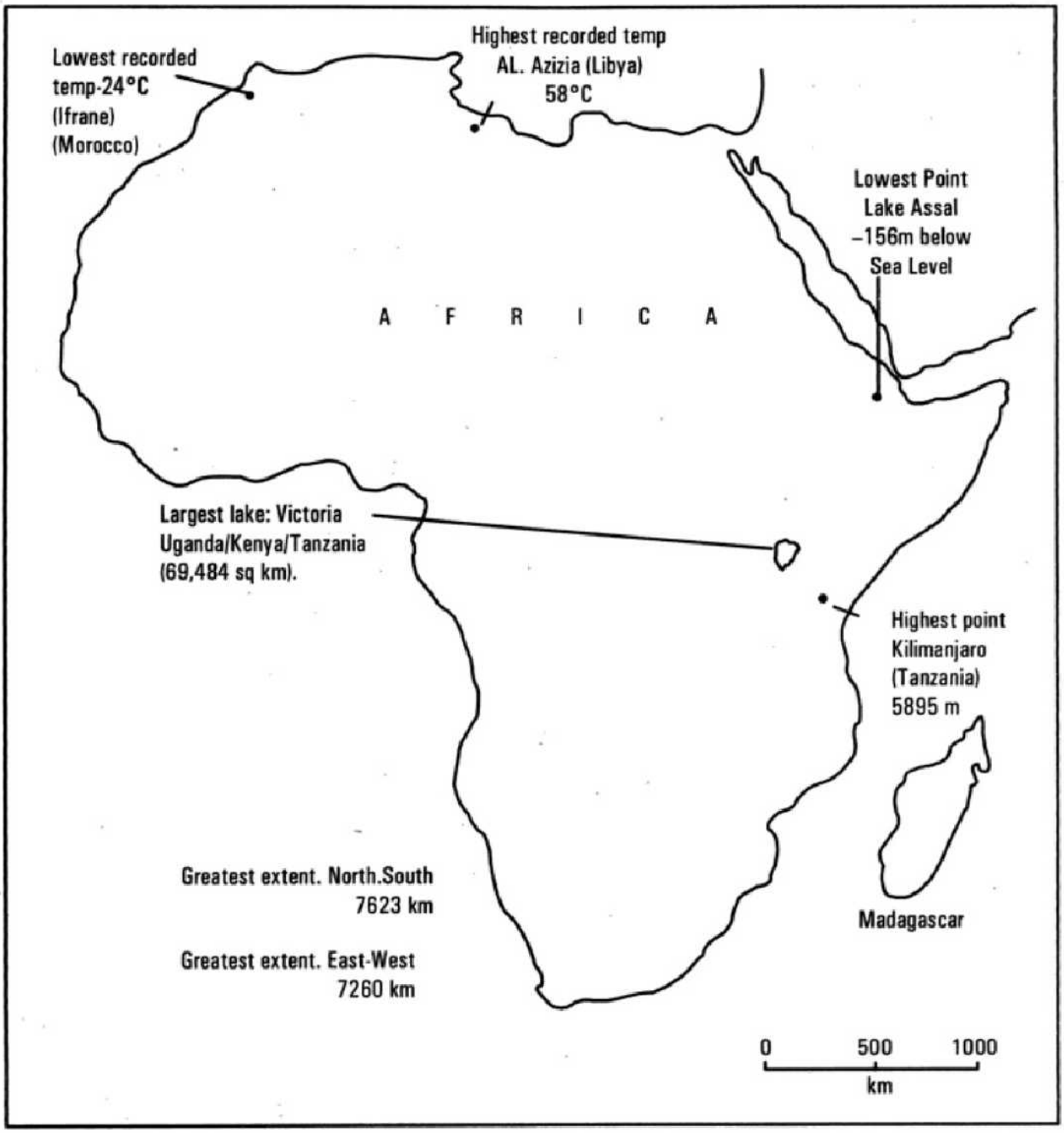
Lowest recorded temp-24°C (Ifrane) (Morocco)
Highest recorded temp AL. Azizia (Libya) 58°C
Lowest Point Lake Assal -156m below Sea Level
A F R I C A
Largest lake: Victoria Uganda/Kenya/Tanzania (69,484 sq km).
Highest point Kilimanjaro (Tanzania) 5895 m
Greatest extent. North.South 7623 km
Greatest extent. East-West 7260 km
Madagascar
0 500 1000
km

Fig. 6.1 – Africa topographic and climatic extremes

Topographic and Climatic Extremes

Highest peak: Mt. Kilimanjaro 5895 m (19,340 ft), Tanzania.

Lowest point: Lake Assal -156m below sea level (Djibouti)

Longest range: Atlas Mountains 2,410 km (1,500 miles)

Highest recorded temperature: 58°C Al-Azizia –Libya **(Fig. 6.1)**

Lowest recorded temperature -24°C Ifrane – Morocco **(Fig. 6.1)**

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Largest Island: Madagascar – 587,041 sq km (26,828 sq miles)
Largest lakes: Lake Victoria – 69,484 sq km (26,828 sq miles)
Second largest lake: Lake Tanganyika 32,900 sq km (12,700 sq miles)
Longest Rivers: Nile – 6,650 km (4,132 miles)
Second largest river: Congo 4700 km (2,900 miles)
Coastline: 30,539 km
The southern most point of Africa: Agulhas

Other Key Physical Features Sahara

Sahel: A semi-arid tropical savanna region which extends for about 4000 km from west (Atlantic Ocean) to east (Arabian Sea). Sahel includes the countries of Senegal, Mauritania, Mali, Burkina Faso, Niger, northern parts of Nigeria, Chad, parts of Sudan, Eritrea, Ethiopia, and Djibouti. The topography of Sahel is mainly flat.
Congo Basin
Great Rift Valley
Katanga Plateau
Bie Plateau
Somali Peninsula
Ethopian Highlands
Karoo : A semi-arid region of South Africa. It is known for sheep rearing.
Veld (Veldt): Refers to wide open fields in South Africa. The low-veld were infested with Tse Tse fly.

Cultural Features

Population

Largest countries by area
Sudan – 2,503,890 sq km
Algeria – 2,381,741 sq km
Congo – 2,345,858 sq km
Largest country by population – Nigeria
Most densely populated country of Africa: Mauritius – 608.2 persons per sq km.
Least densely populated: Western Sahara – 1 person per sq km
Minerals: Africa has rich mineral deposits. Diamonds are a major deposits in Africa. About 95% of the world's diamonds come from Africa. Botswana produces 35%, Congo 34%, South Africa (Kimberly) 17% and Angola 8% of the total output of diamond in Africa.

Table 6.5: *Leading Agricultural Producers in Africa*

Agricultural product	*Leading producer*
Coffee	Liberia
Cocoa	Ghana
Coconut	Tanzania
Cotton	Egypt
Cloves	Zanzibar
Date-palm	Nigeria
Fruits and vegetables	South Africa
Maize	South Africa
Oil palm	Nigeria
Rubber	Liberia
Sisal	Tanzania
Tea	Kenya
Wheat	South Africa
Wool	South Africa

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Table 6.6: Minerals Production in Africa

Mineral	*Leading producer*
Antimony	South Africa
Bauxite	Guinea
Chromium	South Africa
Copper	Zaire
Diamond	Batswana and Zaire
Gold	South Africa
Iron ore	South Africa
Manganese	South Africa
Petroleum	Nigeria
Phosphate	Morocco
Platinum	South Africa
Tungsten	Zaire
Vanadium	South Africa

Akosombo Dam is located on River Volta
Clove-bowl of the world: Zanzibar and Pemba
Cobora Bassa Dam is located on Zambezi
Countries of Africa which were never colonized: Ethiopia and Liberia
Kainji Dam is located on Niger River
Land of oil-palm: Nigeria
Largest producer of Sisal in Africa: Tanzania
Largest waterfall in Africa: Victoria
South African farmers of Dutch origin: Boer

Table 6.7: Old and New Names of African Countries/Cities

Old name (city/country)	*New name (city/country)*
Elizabethville	Lumbashashi
Gold Coast	Ghana
Katanga	Shaba
Leopoldville	Kinshasa
North Rhodesia	Zambia
Nayasaland	Malawi
Stanleyville	Kisangani
South Rhodesia	Zimbabwe
South-west Africa	Namibia
Zaire	Democratic Republic of Congo

2. Antarctica

Antarctica is a single continent located almost entirely south of the Antarctic Circle. Antarctica means *'Opposite the Arctic'*. It is the fifth largest and the highest continent on the Earth because of the great thickness of ice. In place, ice depth can reach 4800 m. It is the world's coldest continent. There is no coastal plain. There are many volcanoes in Antarctica, some of them still active in Antarctica Peninsula. The ice and snow covers 98 per cent of Antarctica's land area which accounts 70 per cent of world's fresh water. Antarctica is rich in copper, gold, nickel, petroleum and platinum.

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Topographic and Climatic Extremes

Highest peak: Vinson Massif 5,140 m **(Fig. 6.2)**

Bentley Sub-glacial Trench : 2,555 m below sea level

Longest range: Trans-Antarctic mountains 3,000 km

Lowest recorded temperature: -88°C–Vostok (Russian Sector)

Largest glacier in the world : Lambert Glacier, 80 km x 300 km **(Fig. 6.2)**

Largest country: There is no country in Antarctica.

Largest research station: McMurdo (U.S.) temporary population: 250 people (winter), 1,000 people (summer)

Indian station in Antarctica: Maitri, Dakshin Gangotri, and Mount Indira **(Fig. 6.2)**

Aurora: During winters, there is continuous night for three months in the polar regions. During this period, curtains of brilliant coloured lights appear on these dark nights. They are caused by magnetic storms in the upper atmosphere. They are called Aurora Australis in the south and Aurora Borealis in the north.

3. Asia

Asia, which shares the landmass with Europe, is the largest and most populous continent. It is the home to over half of the world's population. It covers about 30 per cent of the land area of the Earth.

Ural Mountain, Ural River, Caspian Sea, Caucasus Mountain, and Black Sea separate it from Europe, while the Red Sea and the Suez Canal separate it from Africa. In the east the Bering Strait separates it from America.

Topographic and Climatic Extremes

Highest point: Mt. Everest – 8848 m **(Fig. 6.3)**

Lowest point: - 392 m – Dead Sea, Israel

Longest ranges: Himalayas 2400 km

Highest recorded temperature: 54°C–Tirat-Tsvi (Israel)

Lowest recorded temperature: -68°C–Verkhoyansk **(Fig. 6.3)**

Ural Mountains 2400 km make a boundary between Asia and Europe

Largest Lake: Caspian Sea–371,000 sq km. **(Fig. 6.3)**

Deepest lake: Lake Baikal 1620 m, 31,499 sq km

Longest River: Chang Jiang (Yangtze Kiang) 6,300 km

The second longest river in Asia: Yenisey River (5,540 km)

The wettest place: Mawsynram – 1080 cm of rain in a year (Meghalaya-India)

The Sundarban-delta, stretching in India and Bangladesh is the largest delta in the world.

Tibet is the highest plateau in the world, often called as the *'Roof of the World'*

Asia is the birth place of Judaism, Christianity, Islam, Confucianism, Hinduism, Buddhism, Jainism, and Sikhism.

Japan is the most developed country in Asia.

Mongolia is the most sparsely populated country of Asia.

The highest density of population in Asia is found in Java Island of Indonesia.

Culturally Asia is divided into:

1. *South West Asia*: It includes Afghanistan, the Peninsula of Arabia, Iran, Iraq, Israel, Jordan, Lebanon, Syria, and Turkey.
2. *South Asia*: This region includes Bangladesh, Bhutan, India, Maldives, Nepal, Pakistan, and Sri Lanka.
3. *South East Asia*: This region consists of Brunei, Indonesia, Laos, Kampuchea (Cambodia), Malaysia, Myanmar, Philippines, and Vietnam.
4. *East Asia*: It includes China, Japan, North Korea, and South Korea.
5. *Central Asia*: It includes the republics of Kazakhstan, Kyrgyzstan, Tajikistan, Turkmenistan, and Uzbekistan.

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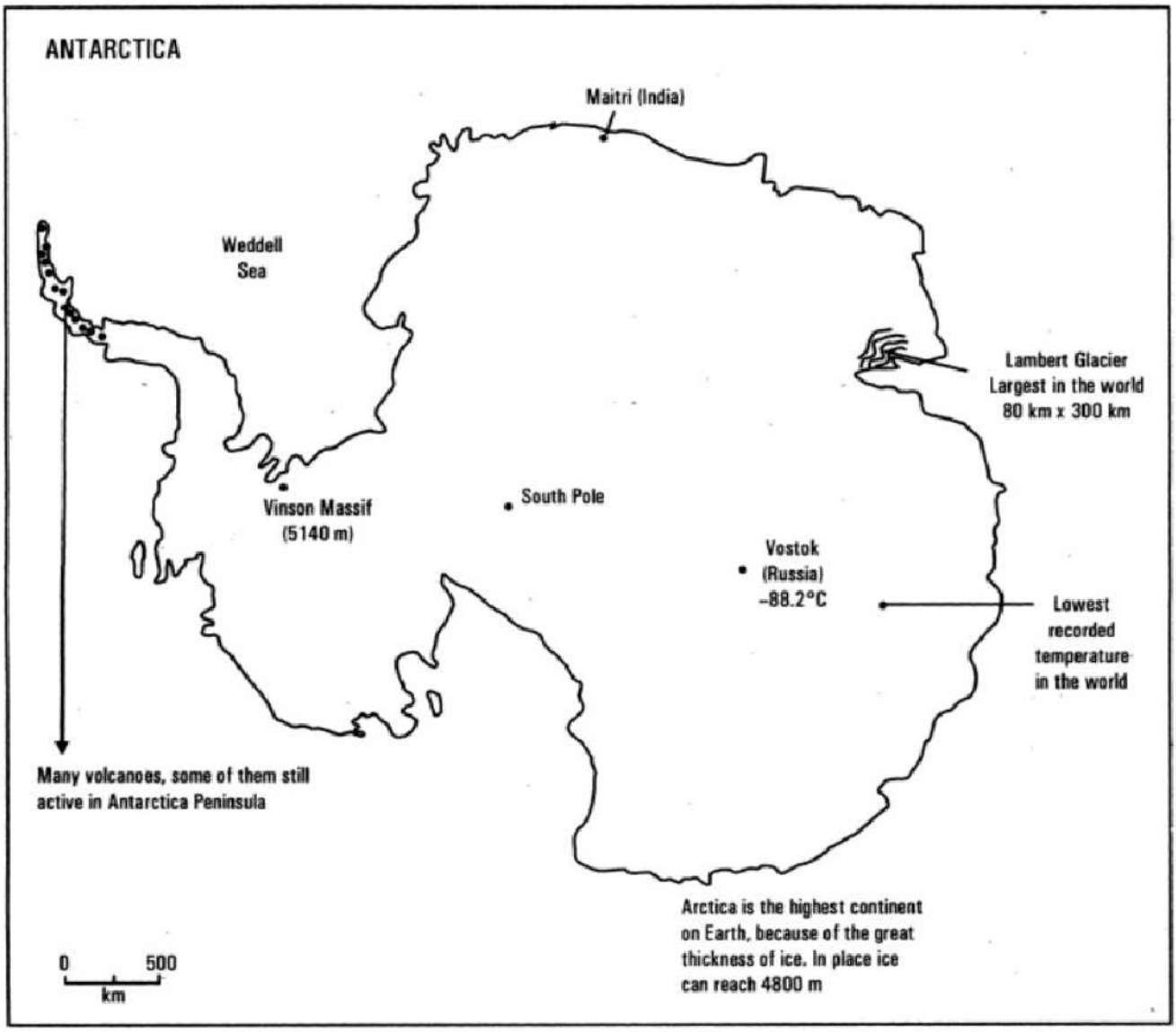

Fig. 6.2 – Antarctica topographic and climatic extremes

6. *North Asia (Siberia)*: The Asiatic part of Russia, sloping towards the Arctic Ocean.

Other Key Physical Features

Western Siberian Plain
Plateau of Tibet
Central Siberian Plateau
Plateau of Iran
Arabian Peninsula
Indo-China Peninsula

Main Deserts of Asia

Dasht-e-Kavir: Iran
Dasht-e-Lut: Iran
Gobi Desert: Mongolia
Karakum: Turkmenistan
Kyzylkum: Kazakhstan and Uzbekistan
Ordos: China
Registan: Afghanistan
Taklamakan: China
Thar-Cholistan Desert: India and Pakistan

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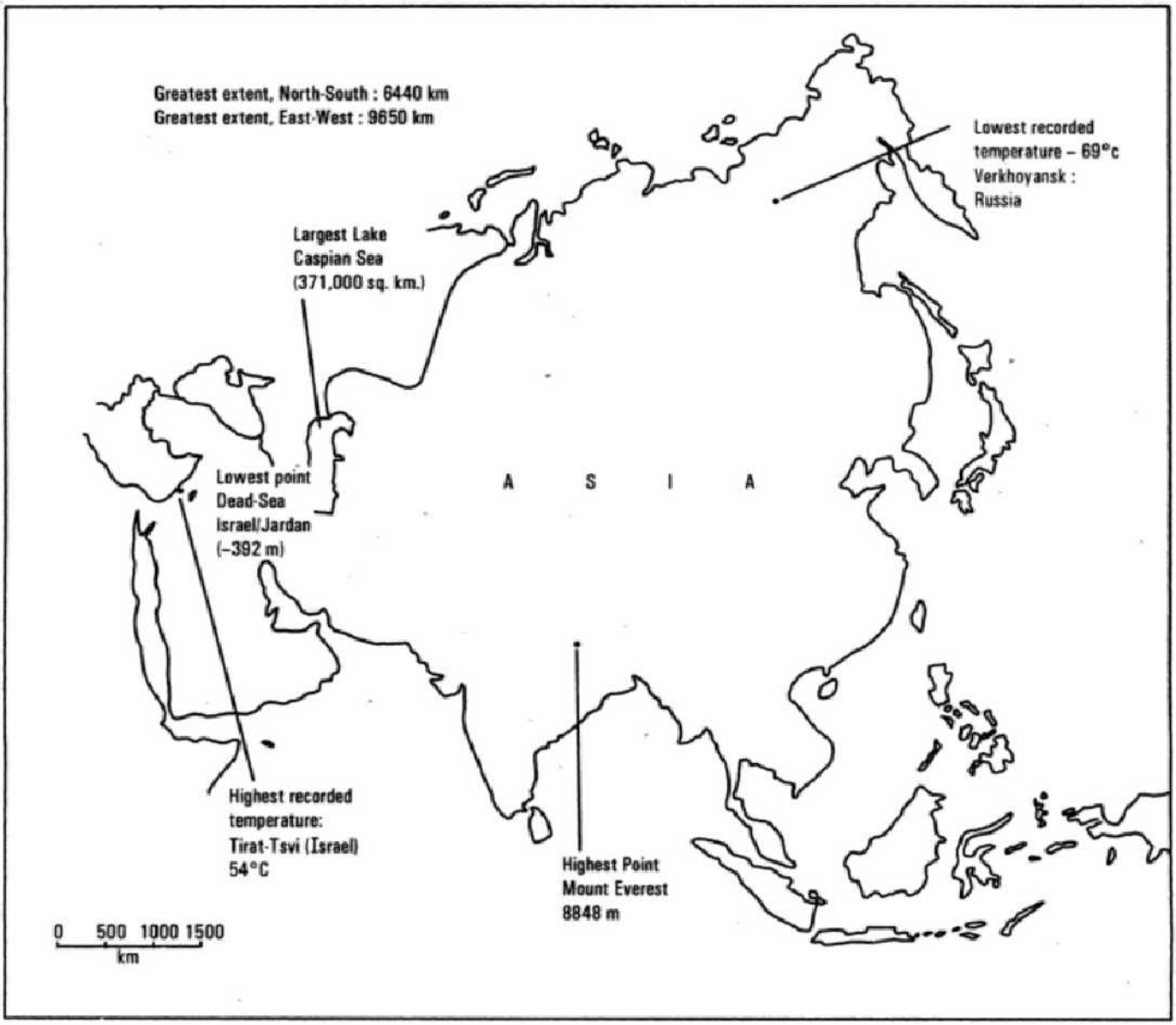
Greatest extent, North-South : 6440 km
Greatest extent, East-West : 9650 km
Lowest recorded temperature – 69°c Verkhoyansk : Russia
Largest Lake Caspian Sea (371,000 sq. km.)
Lowest point Dead-Sea Israel/Jardan (–392 m)
A S I A
Highest recorded temperature: Tirat-Tsvi (Israel) 54°C
Highest Point Mount Everest 8848 m
0 500 1000 1500
km

Fig. 6.3 – Asia topographic and climatic extremes

Cultural Features

Total population of Asia: 3,957,700,000

Total area of Asia: 17,075,400 sq km

Largest country by area:
China–9,572,900 sq km

Largest country by population:
China –1,313,973,713

Second largest population:
India – 1210 million (census 2011)

Most densely populated country: Singapore–6,455 persons per sq km

Least densely populated country: Mongolia – 1.8 persons per sq km

Largest urban area: Tokyo (Japan)–35,197,000

Second largest city: Mumbai (India)– 18,196,000

4. Australia and Oceania

Australia and Oceania are famous for their thousands of beautiful tropical islands and for their diverse cultures and languages. Australia is the smallest continent. Unique plants and animals can be found throughout the isolated islands of Oceania.

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Topographic and Climatic Extremes

Highest peak: Mt. Wihelm (Papua-New Guinea) – 4509 m
Highest peak in Australia: Mt. Kosciusko (2230 m)
Lowest point: -16 m below sea level (Lake Ayre)
Highest recorded temperature: 53°C at Bourke, New South Wales **(Fig. 6.4)**
Lowest recorded temperature: -22°C Canberra **(Fig. 6.4)**
Longest range: Great Dividing Range –3700 km
The Tropic of Capricorn divides the continent into almost two equal parts
Largest lake: Lake Ayre (8884 sq km)
Largest Island: New Guinea
South Island: New Zealand
Largest lake: Lake Ayre – 9583 sq km
Longest river: Murray –1930 km
Second longest river: Darling–1879 km
Deserts of Australia: Gibson Desert, Great Sandy Desert, Great Victoria Desert, Little Sandy Desert, Rangipo Desert, Simpson Desert, Strzelecki Desert, Western Desert.

Other Key Physical Features

Great Artesian Basin Nullarbor Plain
Kimberly Plateau
Western Plateau

Cultural Features

Population: 33,100,000
Largest Country: Australia – 7,692,208 sq km
By population: Australia – 20,264,082
Population density:
Most densely populated: Nauru–626 persons per sq km.
Least densely populated: Australia – 2.6 persons per sq km
Maoris: Aborigines of Australia
Largest city of Australia: Sydney (4,331,000)
Second largest city of Australia: Melbourne – 3,626,000
Largest city of New Zealand: Auckland
The labourers working in the sheep stations (ranches) of Australia are known as: *Jackaroos*
The largest state of Australia: Western Australia
Lead, silver and zinc producing centers: Mt. Isa and Broken Hill
Downs: Temperate grasslands of Australia

5. Europe

Europe, which shares landmass with Asia, is the second most densely populated continent. It is the second smallest continent in the world after Australia. Birthplace of modern industry, the European economies are dominated by manufacturing, and the level of productivity has been high; level of development generally decline from west to east. Europe's rapidly aging population is generally well off, highly urbanized, well educated, and enjoys long life.

Topographic and Climatic Extremes

Highest peak: Mt. Elburs: 5642 m (Georgia-Russia)
The highest peak of Alps Mountain : Mt Blanc (4807 m)
Lowest point: -28 m, Caspian Depression – Russia, **(Fig. 6.5)**
Largest range: Ural Mountains
Highest recorded temperature: 50°C, Seville (Spain)
Lowest recorded temperature: -55°C Ust-Shchugor (Russia)
Germany is the second most populous country of Europe after Russia.
The density of population is the highest in the Netherlands.
Rotterdam also known as *Europort* (Netherlands) is the largest port in Europe.
Moscow and Paris are the only two mega cities in Europe having a population of more than 8 million each.
London is the third largest city in Europe after Moscow and Paris.
Benelux countries include Belgium, Netherlands and Luxembourg.

Largest Island

Great Britain – 229,898 sq km

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Largest Lakes

Caspian Sea (located both in Asia and Europe) 371,800 sq km
Lake Ladoga (Ladozhskoye Ozero)–17,703 sq km

Longest Rivers

Volga – 3,530 km
Danube – 2850 km

Other Key Physical Features

Caucasus Mountains, Alps, Apennines, Carpathian Mountains, and Pyrenees

Northern European Plain
Central Russian Upland
Scandinavian Peninsula
Iberian Peninsula: Portugal and Spain
Balkan Peninsula
Dogger Bank: The most important fishing ground of Europe
The longest river of Europe: Volga
The low countries: Belgium, Netherlands and Luxemburg
The city known as key to Baltic: Copenhagen
The land reclaimed from the sea: Polder (Netherlands)

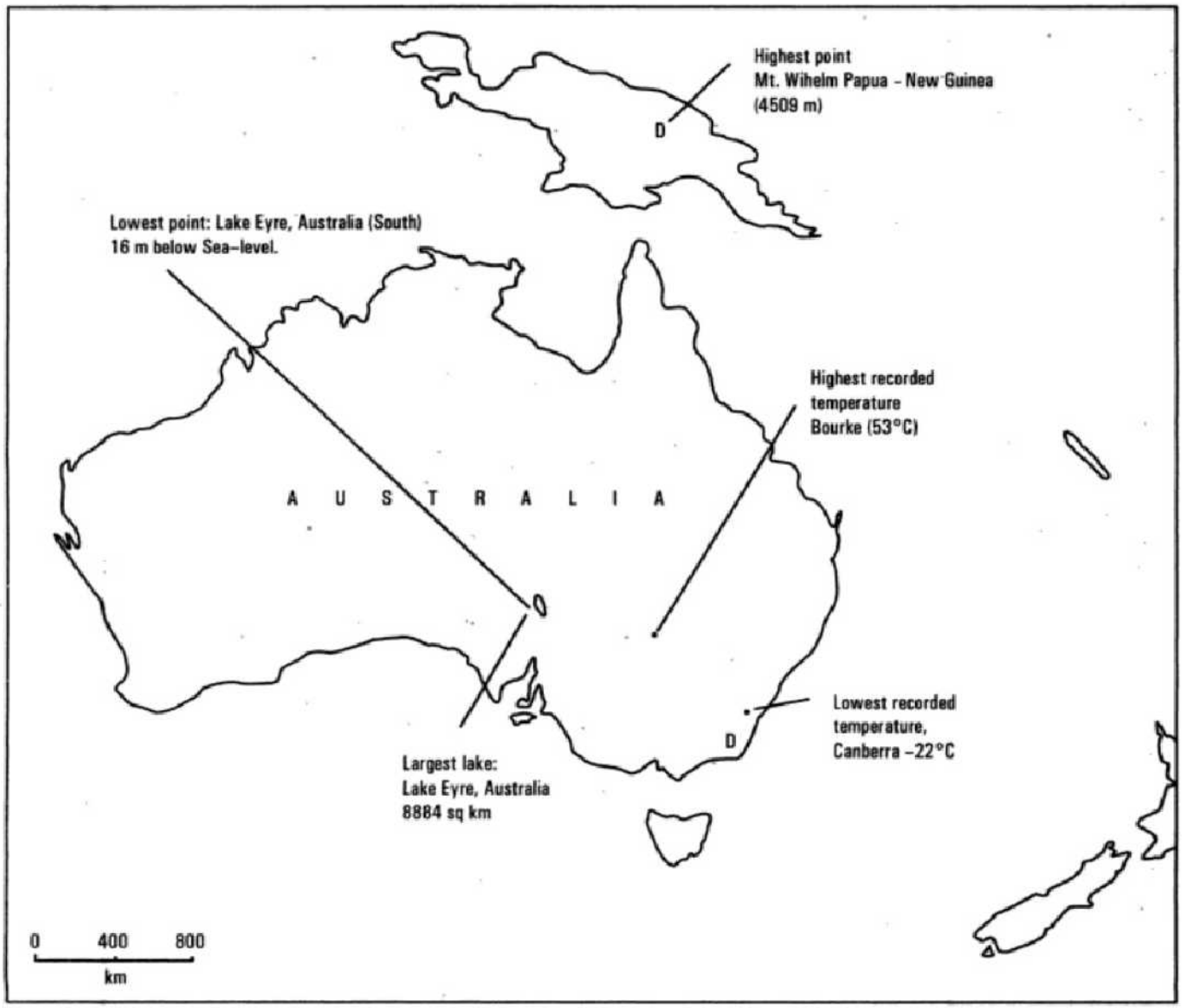

Fig. 6.4 – Australia – Topographic and climatic extremes

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The key to the Mediterranean: Strait of Gibraltar
The light house of Mediterranean: *Mt.* Stramboli
The smallest sovereign state of the world: Vatican City
The country with highest per capita out put of hydel power in the world: Norway

Cultural Features

Population: 727,700,000
Largest Country
By area: Russia–17,075,400 sq km
By population: Russia–142,893,540

Population Density

Most densely populated: Monaco–16,690 persons per sq km
Least densely populated– Iceland: 7.5 persons per sq km

Largest Urban Areas

Moscow (Russia)–10,654,000
Paris (France)–9,794,000

Peculiar Features of Europe

The most northerly capital of the world: Reykjavik (Iceland)

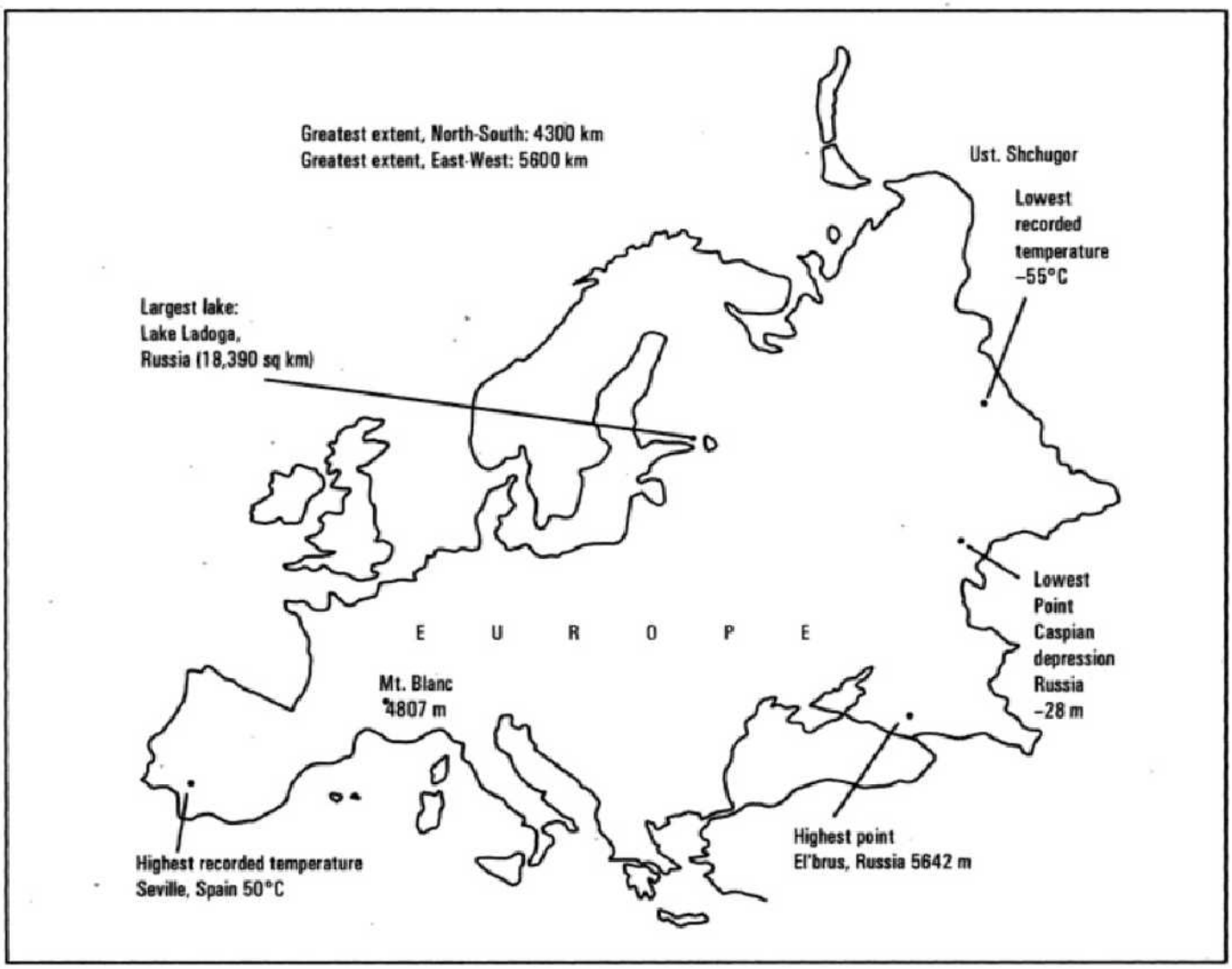
Greatest extent, North-South: 4300 km
Greatest extent, East-West: 5600 km
Ust. Shchugor
Lowest recorded temperature –55°C
Largest lake: Lake Ladoga, Russia (18,390 sq km)
E U R O P E
Lowest Point Caspian depression Russia –28 m
Mt. Blanc 4807 m
Highest point El'brus, Russia 5642 m
Highest recorded temperature Seville, Spain 50°C

Fig. 6.5 – Europe – Topographic and climatic extremes

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6. North America

North America is the third largest continent with a total area of 24,238,000 sq km including Greenland and the Caribbean Islands. It includes two of the world's largest countries, i.e. Canada and United States (U.S.A). People with ancestors from Europe, Africa, Asia, and the Americas (Red Indians) share the plains and mountainous regions of North America.

Topographic and Climatic Extremes

Highest peak: Mt. McKinley–6194 m, Alaska (USA)
Second highest peak: Mount Logan–5959 m (Canada)
Longest range: Rocky Mountain–4,800 km
Lowest point: -86 m, Death Valley California, U.S.A. **(Fig. 6.6)**
Highest recorded temperature: 57°C, Death Valley, California (USA)
Lowest recorded temperature: -66°C, Northice (Greenland)

Cordilleras

The term is used to the folded Rockies as they resemble to the twisted cord. Cordilleras are part of the Pacific Ring of Fire.
Mississippi River (length 3751 km): Originates in Minnesota State, making a bird-foot delta, merges into the Gulf of Mexico. Missouri, its longest right hand, tributary merges makes confluence at the city of St. Louis.

The tallest trees of the world (sequoias, douglas-fir, red-wood, etc.) are found in the temperate rainy climate in the state of California and Oregon, and Columbia.

Chaparral

The mediterranean vegetation in the state of California is known as *chaparral*.

Prairies

The temperate grasslands of U.S.A. and Canada.
Chinook (snow eater): Local warm wind descending on the eastern slopes of the Rockies.
Canada is divided into 10 provinces and 3 territories (Yukon, North-West Territories and Nunavut).

U.S.A. consists of 50 states including Alaska and Hawaii.

New York, Los Angles, Chicago and Houston are the largest cities of U.S.A. in a descending order of population.

Delaware (U.S.A.) and Prince Edward Island (Canada) are the most densely populated islands of the USA and Canada, respectively.

Deserts of North America

Baja-California desert, Carcross desert, Chihuauan desert, Colorado Plateau, Great Basin, Moab desert, Mohave desert, Mojave desert, Nk'mip desert, Painted desert, Sonoran desert (Mexico), and Yuha desert.

***Table 6.8:** Leading Producers of Agricultural Products*

Agricultural product	*Leading producing state(s)*
Apples	Nova Scotia (Canada)
Barley	Alberta (Canada)
Corn	Illinois (U.S.A.), Ontario (Canada)
Cotton	Texas
Grapes	California
Groundnuts	Georgia
Oranges	Florida
Rice	Arizona
Sugarcane	Florida
Tobacco	Kentucky

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Mining Centres

Iron ore

Mesabi, Marquette (Minnesota), Vermillion (South Dakota), Albama, Red Mountains, New Jersey, Pennsylvania.

Copper

Arizona, Minnesota, Michigan, Montana, Nevada, Tennessee and New Mexico.

Gold

Alaska (Yukon River Valley), Arizona, Colorado, Idaho, Montana.

Iron & Steel Industrial Centres:

Alentown, Baltimore, Buffalo, Camdon, Chicago, Cleveland, Detroit, Gary, Lorrain, Lowell, Milwakee, Morrisville, Phillisburg, Pittsburg, Sparrow-point, St. Louis, Toledo (U.S.A.), Bell Island, Hamilton, Niagara, Nova Scotia, Port Colborne, St. Marie, Toronto (Canada).

Table 6.9: *Leading Industrial Centres of U.S.A.*

Industry	*Leading industrial centre*
Aeroplanes	Atlanta, Baltimore, Buffalo, Los Angles, San Diego and Seattle
Agricultural machinery	Chicago, Cincinnati, Winnipeg
Cotton textile	Lowell and Lawrence to the North of Boston, Texas
Film industry	Los Angles (California)
Glass industry	Toledo
Motor cars and vehicles	Detroit, Cleveland and Buffalo
Petrochemicals	Houston
Rails and wagons	Chicago and Philadelphia
Rubber and tyres	Akron
Ship-building	Delaware, San Diego, New York

Largest Island

Greenland: 2,166,066 sq. km.

Largest lakes

Lake Superior: 82,103 sq km
Lake Huron: 59,570 sq. km.
Lake Michigan: 57,760 sq. km.
Longest River: Mississippi-Missouri System-6020 km.
Mackinzie: 4,241 km.

Major Dams of Canada

Cascade Dam (Colorado River), Barrier Dam (British Columbia), Ghost Dam, Great Falls Dam (South Carolina), Peace Canyon Dam (Alberta-Canada), Seven Sisters Dam (Texas), Tinker Dam.

Major Dams of USA

Buchanan Dam (Colorado River), Davis Dam (Colorado River), Glen Canyon Dam (Colorado River), Hoover Dam (Colorado River), Parker Dam (Snake River), Swan Falls Dam (Snake River)

Other Key Physical features

Great Basin	Canadian Shield
Great Plains	Labrador Peninsula
Coastal Plains	Yucatan Peninsula
Colorado Plateau	Florida Peninsula
Plateau of Mexico	

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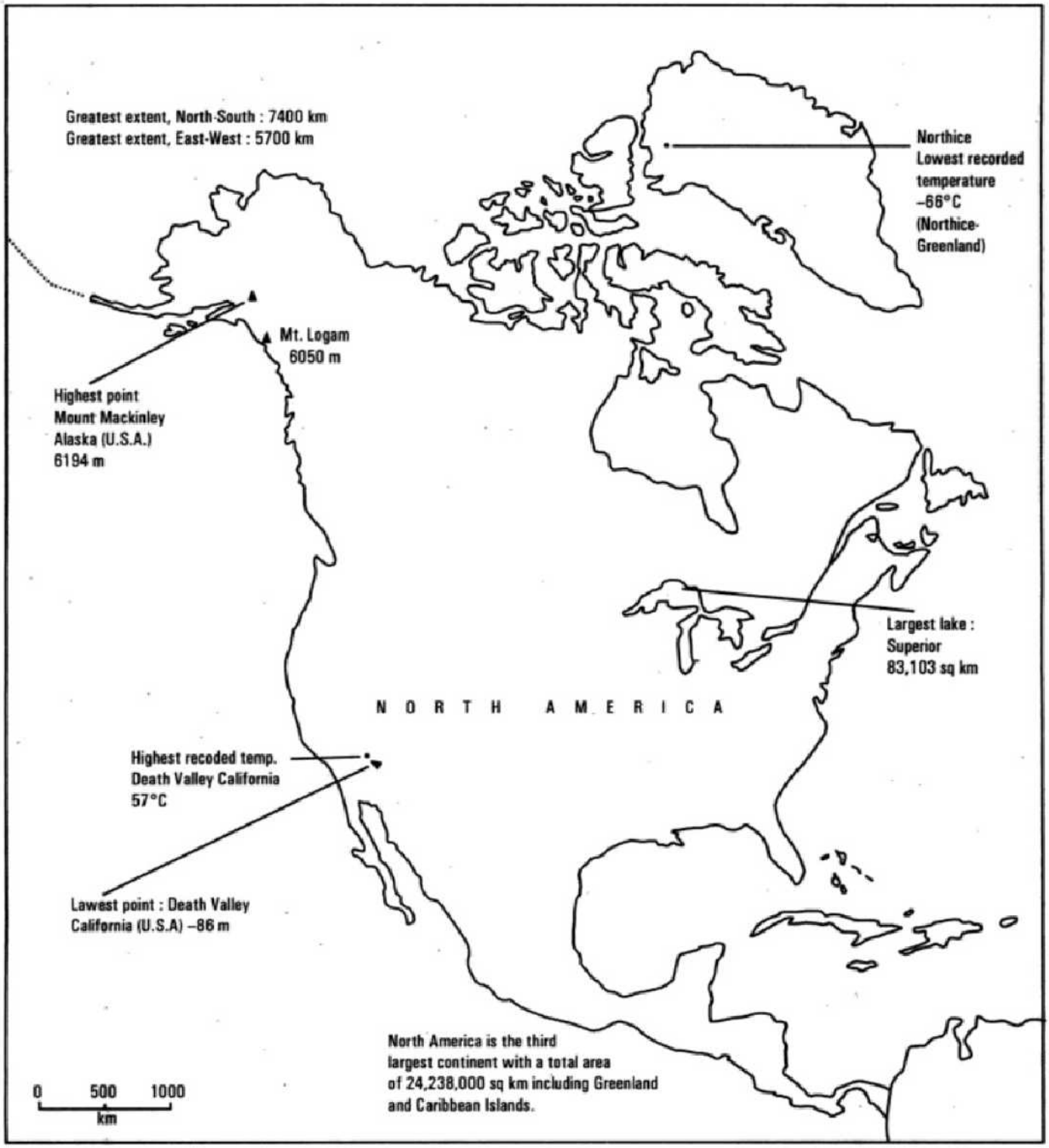

Fig. 6.6 – North America – Topographic and climatic extremes

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Cultural Features

Population: 618,200,000

Largest Countries

By area: Canada – 9,984,670 sq km

United States: 9,522,058 sq km

U.S.A states in descending order of area: Alaska, Texas, California, Montana

Smallest state of U.S.A.: Rhode Island

Most populated state of U.S.A.: California

The latitude making boundary between Canada and U.S.A.: 49°N

The busiest waterway of North America: St Lawrence River

The Canadian Pacific Railway runs between: St. John's in New Brunswick and Vancouver

The Canadian Railway connects: Halifax to Prince Rupert (British Columbia)

The Canal joining lake Erie with Ontario: Welland Canal

The highest tidal range recorded in the Bay of Funday

The Hoover Dam lies on Colorado River

The hottest and driest place of U.S.A.: Death Valley

The iron & steel capital of the world: Pittsburg

The largest city of Canada: Toronto

The largest province of Canada: Quebec

The largest producer of paper and pulp in the world: Canada

The longest river of Canada: Mackenzie which drains into the Beaufort Sea

The most populated province of Canada Ontario

The most recent federal territory of Canada: Nunavut

The Niagra Falls lie between U.S.A. and Canada

The 'Old Faithful Geyser' lies in Yellowstone National Park (Wyoming–U.S.A.)

Population Density

Most densely populated: Barbados: 651 persons per sq km

Least densely populated: Greenland – 0.03 persons per sq km

Inuit (Eskimos) in Alaska, Canada and Greenland

Metis (mixed race) in Canada (native people). The indigenous people speak the Ojibwa, Cree, Inuit and Inukitut languages.

In U.S.A. there are 1.9 million native Americans, half of whom live in 300 reservations. The largest minorities are of African origin, constituting 11 per cent and Asians 8 per cent of the total population.

The main ethnic groups of U.S.A. are: Cherokee (16% of total native American population), Navajo (12%), Chippewa (5%), Lakota (5%), Choctaw(4%) , Pueblo, Apache, Iroquis, Lumbee, Creek (3%), and Blackfoot (2%).

Largest Urban Areas

Mexico City (Mexico)–19,411,000
New York City (U.S.A.)–18,718,000
Los Angles (U.S.A.)–12,298,000

7. South America

South America is the fourth largest continent in the world, after Asia, Africa, and North America.

South America is known for its lively and diverse cities, towering Andes Mountains and the Amazon Rain Forest (*Selvas*) – the largest rain forest in the world.

Topographic and Climatic Extremes

Highest peak: Mt. Aconcagua–6,959 m **(Fig. 6.7)**

Lowest point: –40m below sea level, Valdes Peninsula, Argentina **(Fig. 6.7)**

Longest range: Andes Mountains – 7,200 km

Highest recorded temperature: 49°C Rivadavia (Argentina)

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Fig. 6.7 – South America – Topographic and climatic extremes

Lowest recorded temperature: –33°C, Sarmiento (Argentina)

Equator passes through the northern part of the continent, while 60° meridian divides the continent into almost two halves.

Largest Island: Tierra del Fuego – 49,935 sq km

Largest lake: Maracaibo (Venezuela), area: 13,512 sq.km.

Highest lake: Lake Titicaca (area–3812 sq km)

The highest waterfall in the world – Angel Falls (979 m), is located on River Churun – a tributary of Caroni which is a tributary of the River Orinoco.

The driest place on Earth: Iqique (Atacama-Chile)

The Pacific coastal plain is the largest in the world.

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The coastline of South America is smooth and regular. South-western coast is characterised with fiords.

Quito – the capital of Ecuador is known as the *'city of eternal spring'*.

Longest Rivers: Amazon, 6,437 km; Parana: 4,880 km

Other Key Physical Features

Amazon Basin

Brazilian Highlands

Guiana Highlands

Patagonia: The temperate desert on the leeward side of Andes in Argentina.

Desert of Atacama: Stretching over coastal Chile and Peru, it is the driest desert in the world in which rainfall has not been recorded for the last 400 years. It is rich in nitrate (Caliche or Chile Saltpeter), iodine and borex. Nitrate is mainly used in the manufacturing of gun-powder, medicines and fertilizers.

Campos: The savanna grasslands of eastern Brazil.

Gran Chaco: Lying to the south of Selvas, these are temperate forests and bushes in south-west Brazil and north-west Argentina.

Llanos: These are the savanna grasslands of Venezuela

Pampas: Pampas are the temperate grasslands of Argentina and Uruguay.

Selvas: These are the equatorial rain-forests of the Amazon Basin (Brazil).

Polygon of Drought: This is a region in the north-east of Brazil which is frequently affected by drought conditions.

Estancias: The ranches of Argentina are called as Estancias.

Fazendas: The coffee plantation farms in Brazil are called as Fazendas.

Guano: The droppings of Guano birds is a valuable fertilizer. These birds are found in thousands on the rocky shores of Chile and Peru.

Southern most inhabited city in the world: Punta Arenas (Chile).

Table 6.10: *Agricultural Products*

Agricultural product	*Leading producer*
Beef	Argentina
Coffee	Brazil
Cotton	Brazil
Fisheries	Peru
Soybean	Brazil
Wheat	Argentina
Sugarcane	Brazil
Sunflower	Argentina

Table 6.11: *Minerals in South America*

Mineral	*Leading producers*
Bauxite	Brazil, Guyana
Coal	Brazil
Copper	Chile
Diamond	Guyana, Venezuela
Gold	Ecuador, Brazil, Guyana

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Iron ore	Brazil
Nitrate	Chile (Desert of Atacama)
Petroleum	Venezuela
Silver	Peru
Tin	Bolivia

Cultural Features

Population: 375,700,000

Largest Countries

By area: Brazil – 8,514,877 sq. km
Argentina: 2,780,092 sq km
By population: Brazil – 188,078,227

Population Density

Most densely populated: Ecuador – 50 persons per sq km.
Least densely populated: French Guyana – 2.4 persons per sq km

Indigenous People of South America: Most of the indigenous people of South America are Red Indians, belonging to the Mongoloid race. These people are mostly living in the Amazon Basin and the Andes Mountains. Some of the important indigenous people of South America are given below:

Ache, Awa, Ayamara, Baniwa, Caiapos, Cocama, Guarani, Juris, Kayapo, Koruba, Mapuche, Matses, Mayoruna, Quilombolo, Shipibo, Shuar, Ticuna, Tupi, Urarina, Yagua, Zaparos, Wai-Wai.

Mestizo: Descendents of the mixed European (Spanish) and Red Indians.

Mulatto: Descendents of the black and whites.

Zambo (Zemb): Latin Americans of mixed African (Negro) and Red Indians.

Largest Urban Areas

Sao Paulo (Brazil)–18,330,000
Buenos Aires (Argentina)–12,550,000
Rio de Janeiro (Brazil)–11,469,000

Table 6.12: Largest Countries (Fig. 6.8)

	Country and continent	*Area in sq km*	*Area in sq miles*
1.	Russia (Europe and Asia)	17,075,400	6,592,800
2.	Canada (North America)	9,984,670	3,855,103
3.	China (Asia)	9,572,900	3,696,100
4.	United States (North America)	9,522,058	3,676,487
5.	Brazil (South America)	8,514,877	3,287,612
6.	Australia (Australia)	7,692,208	2,969,978
7.	India (Asia)	3,166,414	1,222,559
8.	Argentina (South America)	2,780,092	1,073,400
9.	Kazakhstan (Asia)	2,724,900	1,052,100
10.	Sudan (Africa)	2,503,890	966,757

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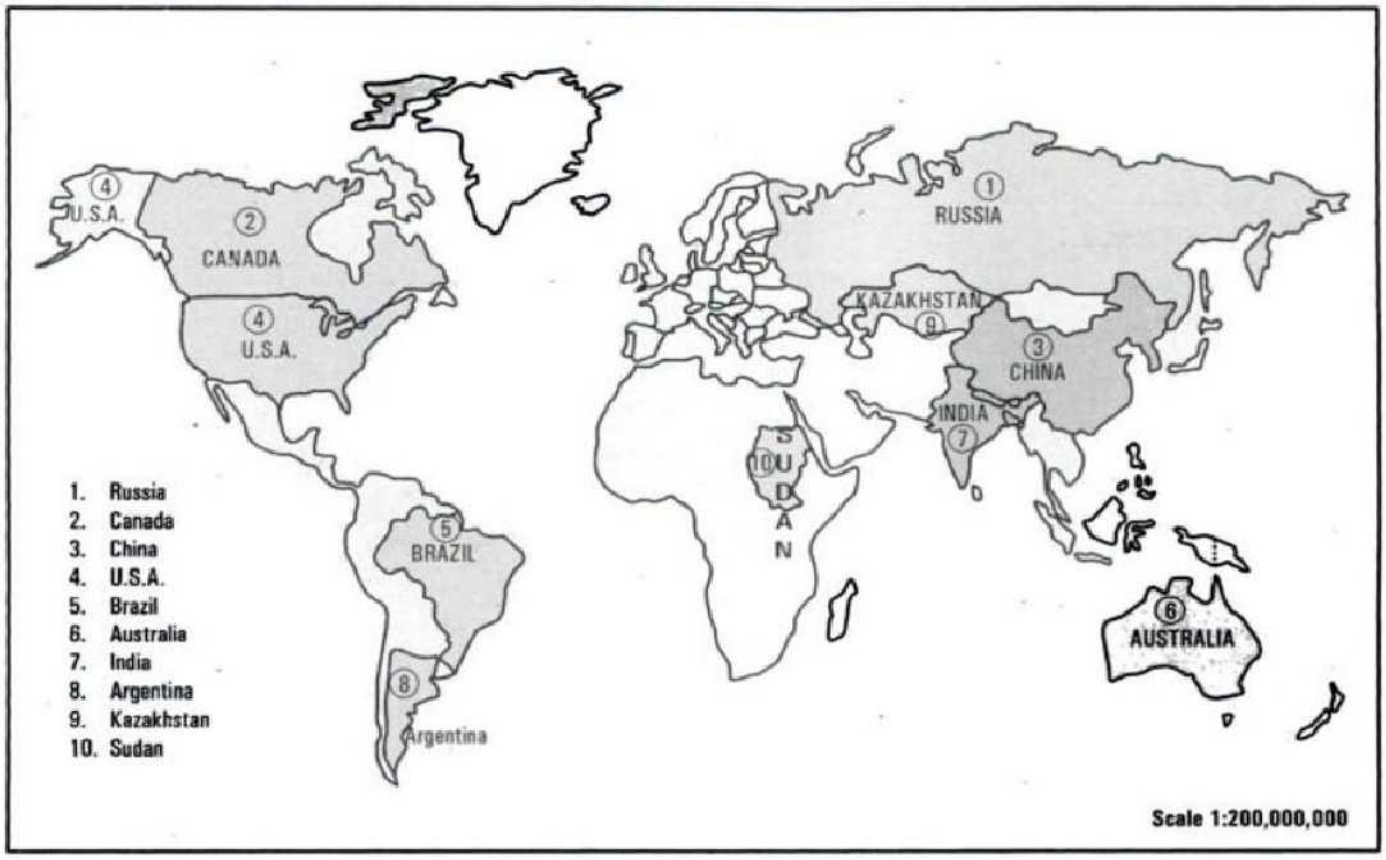

Fig. 6.8 – Largest countries of the world by area

***Table 6.13:** The Smallest Countries of the World*

	Country	*Location*	*Area in sq km*
1.	Vatican City	Europe	0.44
2.	Monaco	Europe	1.95
3.	Nauru	South Pacific	21.10
4.	Tuvalu	South Pacific	26.00
5.	Sam Marino	Europe	61.00
6.	Liechtenstein	Europe	160.00
7.	Marshall Islands	Central Pacific	181.00
8.	St. Kitts-Nevis	Caribbean Sea	269.00
9.	Maldives	Indian Ocean	298.00
10.	Malta	Mediterranean Sea (Europe)	316.00

Table.6.14:** Major Mountains and Peaks of the World **(Fig.9)

	Mountains and Peaks	*Continent/Country*
1.	Atlas	Morocco (Africa)
2.	Drekensberg	South Africa
3.	Mt. Kilimanjaro	Tanzania

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4.	Mt. Tobkul	Morocco (Africa)
5.	Altai	Kazakhstan and Mongolia (Asia)
6.	Arakanyoma	Myanmar, North-East India (Asia)
7.	Chukot Range	Siberia (Russia)
8.	Elburz	Iran (Asia)
9.	Great Khingan	China
10.	Himalaya	India, Nepal, Bhutan, Pakistan, Tibet (China),
11.	Hindukush	Afghanistan, Pakistan, Tajikistan
12.	K^2	Jammu & Kashmir (India)
13.	Kun Lun	China
14.	Mt. Everest	Nepal and Tibet (China)
15.	Pegu-Yoma	Myanmar and Thailand
16.	Puncak-Jaya	New Guinea (Indonesia)
17.	Sayan	Siberia (Russia)
17	(a).Yablonovy	Siberia (Russia)
18.	Stanovoy Range	Siberia (Russia)
19.	Tarus	Turkey (Asia)
20.	Tien-Shan	Xinjiang(Sinkiang- China), and Kyrgyzstan
21.	Tnasarum-Yoma	Thailand (Asia)
22.	Verkhoyansk	Siberia (Russia)
23.	Zagros	Iran (Asia)
24.	Alps	Switzerland, France
25.	Appenine	Italy (Europe)
26.	Carpathian	Romania (Europe)
27.	Caucasus.	Armenia, Azerbaijan and Georgia
28.	Elbrus	Georgia and Russia (Europe)
29.	Kjolen Mt.	Norway (Europe)
30.	Mt. Blanc	France (Europe)
31.	Pyrenees	France/Spain (Europe)
32.	Tatry	Carpathian Mt. Romania (Europe)
33.	Urals	Russia
34.	Alaska Range	U.S.A. (North America)
35.	Appalachian	U.S.A. (North America)
36.	Brook Range	Alaska (North America)
37.	Coast Range	U.S.A. (North America)
38.	Mt.Mckinley	Alaska (U.S.A.)
39.	Rockies	Canada and U.S.A. (North America)
40.	Aconcagua	Argentina and Chile (South America)
41.	Cerro Ojes del Saldo	Argentina and Chile (South America)
42.	Chimbrozo	Quito (Ecuadaor)
43.	Cotopaxi	Ecuador (South America)
44.	Toro	Argentina and Chile (South America)

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Table 6. 15: Highest Peaks of the World

	Mountain Peak and Continent/country	*Height in metres*
1.	Everest, Asia	8848
2.	K^2 (Godwin Austin), Asia	8611
3.	Kanchenjunga, Asia	8586
4.	Lhotse I, Asia	8516
5.	Makalu, Asia	8463
6.	Cho Oyu, Asia	8201
7.	Dhaulagiri, Asia,	8167
8.	Manaslu I, Asia	8163
9.	Nanga Parbat, Asia	8125
10.	Annapurna I, Asia	8091
11.	Gasherbrum I, Asia	8068
12.	Broad Peak, Asia	8047
13.	Gasherbrum II, Asia	8035
14.	Shishma Pangma (Gosainthan), Asia	8013
15.	Annapurna II, Asia	7937
16.	Gyachung Kang, Asia	7897
17.	Disteghil Sar, Asia	7882
18	Himalchuli, Asia	7864
19.	Nuptse, Asia	7841

Source: **The Nystrom Desk Atlas,** *p.35,* 2008, Nystrom Herff Jones Education Divission.

Table 6. 16: World–Major Rivers ***(Fig.6.10)***

	River and Continent	*Length in km*
1.	Nile, Africa	6650
2.	Amazon, South America	6437
3.	Yangtze, Asia	6300
4.	Mississippi-Missouri, North America	6020
5.	Yenisey	5540
6.	Huang Ho, Asia	5464
7.	Ob, Asia	5409
8.	Parana	4880
9.	Congo	4700
10.	Amur, Asia	4444
11.	Lena, Asia	4400
12.	Mekong, Asia	4350
13.	Mackenzie, North America	4241
14.	Niger, Africa	4200
15.	Zambezi, Africa	3540

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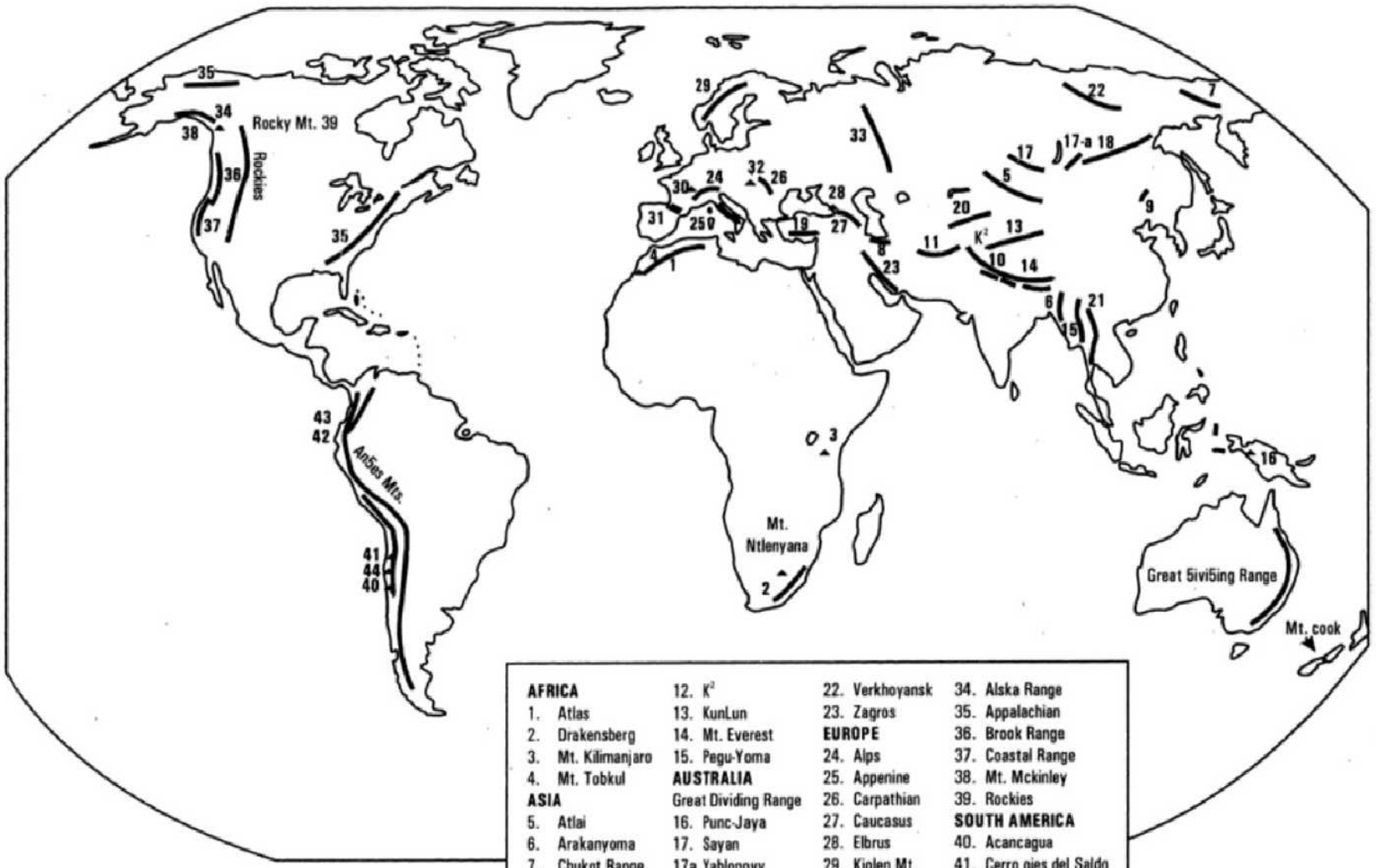

AFRICA
1. Atlas
2. Drakensberg
3. Mt. Kilimanjaro
4. Mt. Tobkul

ASIA
5. Atlai
6. Arakanyoma
7. Chukot Range
8. Elburz
9. Great Khingan
10. Himalayas
11. Hindukush
12. K²
13. KunLun
14. Mt. Everest
15. Pegu-Yoma

AUSTRALIA
Great Dividing Range
16. Punc-Jaya
17. Sayan
17a. Yablonovy
18. Stanovoy
19. Tarus
20. Tien-shan
21. Tnasarum-Yoma
22. Verkhoyansk
23. Zagros

EUROPE
24. Alps
25. Appenine
26. Carpathian
27. Caucasus
28. Elbrus
29. Kjolen Mt.
30. Mt. Blanc
31. Pyrenees
32. Tatry
33. Urals
34. Alska Range
35. Appalachian
36. Brook Range
37. Coastal Range
38. Mt. Mckinley
39. Rockies

SOUTH AMERICA
40. Acancagua
41. Cerro ojes del Saldo
42. Chimbrozo
43. Cotopaxi
44. Toro

Fig. 6.9 – Major mountains and peaks of the world

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16.	Volga, Europe	3530
17.	Madeira, South America	3350
18.	Jurua, South America	3243
19.	Purus, South America	3211
20.	Yukon, North America	3185

Source: **The Nystrom Desk Atlas**, *2008*, p.2, Nystrom Herff Jones Education Division,

Landlocked Countries

A country with no access to sea is known as a landlocked country. There are 42 landlocked countries in the world, ranging in size from the tiny Vatican City to Mongolia. One important preoccupation of a landlocked country is access to the sea. This may be achieved along a river like the Danube, by the creation of corridor, or simply by negotiating a right to passage through the maritime neighbour. The landlocked countries of the world are given in **Table 6.17** and plotted in **Fig. 6.11.**

Largest Islands of the World

The first ten largest islands in respect of area have been shown in **Fig.6.12**, while **Fig.6.13** shows their relative positions in the world map.

Table 6.17:** Landlocked Countries of the World **(Fig.6.11)

Africa (15)	Burundi, Burkina-Faso, Botswana, Central African Republic, Chad, Ethiopia, Lesotho, Malawi, Mali, Niger, Rwanda, Swaziland, Uganda, Zambia, Zimbabwe
Asia (10)	Afghanistan, Bhutan, Kazakhstan, Kyrgyzstan, Laos, Mongolia, Nepal, Tajikistan, Turkmenistan, Uzbekistan
Europe (15)	Armenia, Azerbaijan, Austria, Belarus, Czech Republic, Hungary, Liechtenstein, Luxembourg, Moldova, Macedonia, Serbia, Switzerland, Slovakia, San-Marino, Vatican City,
South America (2)	Bolivia, Paraguay

Table 6.18:** Major Islands of the World **(Figs. 6.12 & 6.13)

	Island	*Area in sq km*
1.	Greeland	2,175,600
2.	New Guinea	805,510
3.	Kalimantan (Borneo)	745,561
4.	Madagascar	587,040
5.	Baffin	507,451
6.	Sumatra	473,606
7.	Honshu	227,414
8.	Great Britain	218,476
9.	Victoria	217,291
10.	Ellesmere	196,236

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Fig. 6.10 – Major rivers of the world

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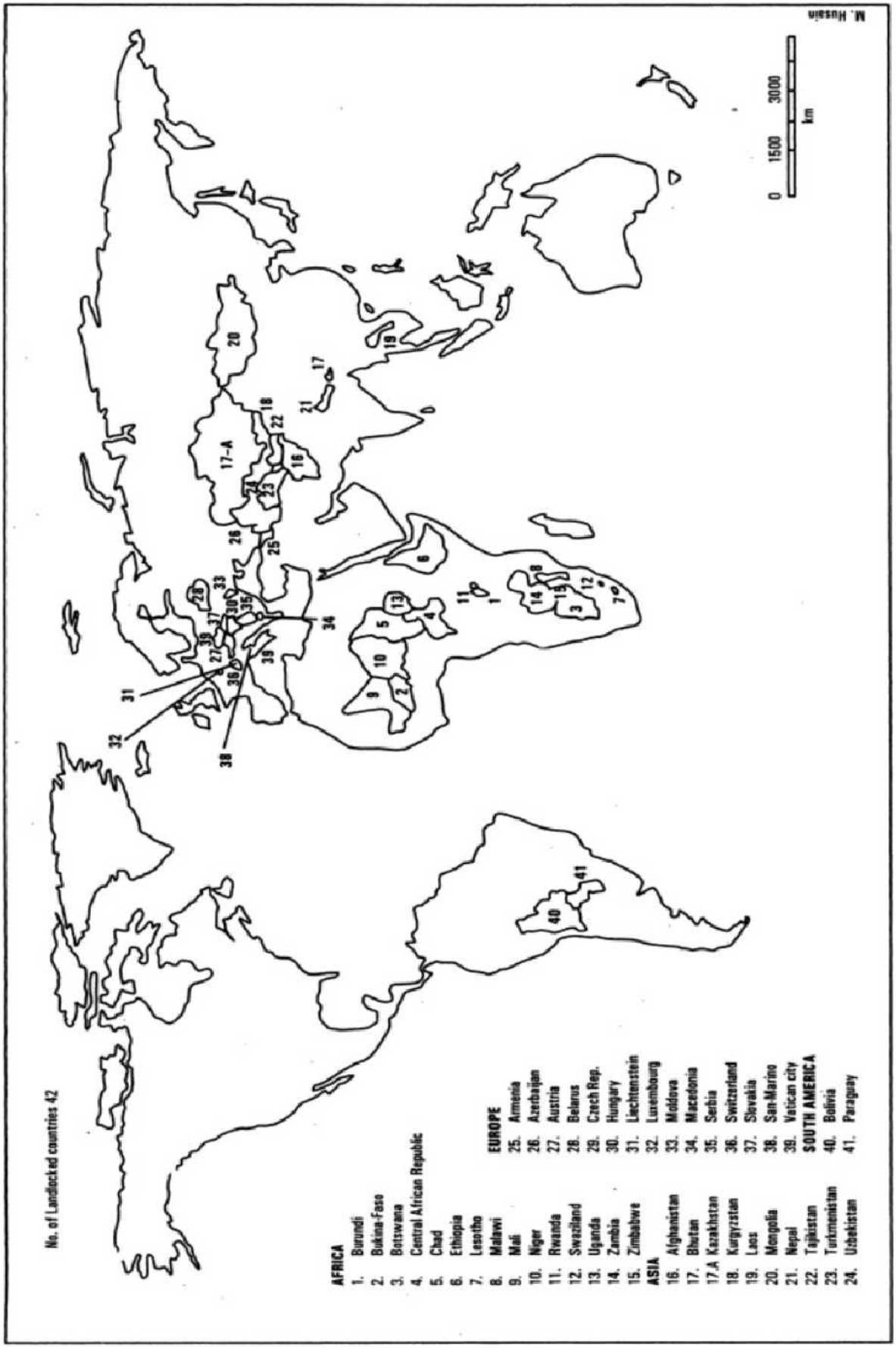

Fig. 6.11 –Landlocked countries of the world

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11.	Sulwasi (Celebes)	174,600
12.	South Island of New Zealand	135,112
13.	Java	132,187
14.	North Island of New Zealand	112,010
15.	Luzon	104,688
16.	New Foundland	103,231
17.	Cuba (main island)	109,860
18.	Iceland (main island)	103,000
19.	Mindanao	97,530
20.	Hokkaido	83,453
21.	Ireland	70,720

1. **Greenland (Inuit-Kalaat-Nunaat):** The largest island in the world, lying to the north-east of North America and mostly within the Arctic Circle. Its total population is about 60,000. Its capital is Nuuk (Godithab). It was discovered and named by the Norse explorer Eric the Red in 986 A.D. and settled in coastal pockets by Norse colonies. Only five per cent of its area is habitable. The economy of Greenland is largely based on inshore and deep-water fishing **(Fig. 6.12)**.
2. **New Guinea (Indonesian-Irian):** New Guinea, the second largest island of the world is an island of the east Malay Archipelago to the north of Australia. It is divided between the independent state of Papua-New Guinea in the east and the Indonesian province of West Irian in the west.
3. **Kalimantan (Borneo)**: A region of Indonesia, comprising the southern part of the island of Borneo. It comprises of the Saba province of Malaysia, the country of Brunie and the Kalimantan province of Indonesia.
4. **Madagascar**: The fourth largest island in the world, Madagascar, lies in the Indian Ocean, off the east coast of Africa from which it is separated by the Mozambique Channel. Antananarivo is its capital. Rich in mica, graphite, and chromite, its chief exports include vanilla, coffee, clove and sugar.
5. **Baffin**: This is the largest island in Canada and the fifth largest in the world. It is situated at the mouth of Hudson Bay. The western part largely remain covered with ice with extensive glaciers. Coastal fishing stations include Frobisher Bay, Cape Dyer, and Cape Dorset.
6. **Sumatra**: It is the seventh largest island of the world, separated from the Malaya Peninsula by the Strait of Malacca. Its largest city and port is Medan. It produces rubber and timber for export and its oil and other minerals provide three-quarters of Indonesian's income.
7. **Honshu:** It is the largest of the four main islands of Japan. Tokyo, Yokohama, Osaka, and Nagoya are situated in this island. The highest mountain of Japan (Mt. Fuji – 3776 m), and the largest Lake Biwa lie on this island.
8. **Great Britain (Britain)**: England, Wales, and Scotland considered as a unit is known as Great Britain. The name is also often used loosely to refer to the United Kingdom.
9. **Victoria:** An island in the Canadian Arctic. It is the 9th largest island in the world. The surrounding region is administered and supplied from Cambridge Bay on the island's south-east coast.
10. **Ellesmere**: It is the northern most island of Canadian Arctic and the third largest island in Canada. It was discovered in 1616 by William Baffin. Fort Conger was the base from which Robert Peary led the first expedition to reach the North Pole in 1909 **(Fig. 6.12)**.

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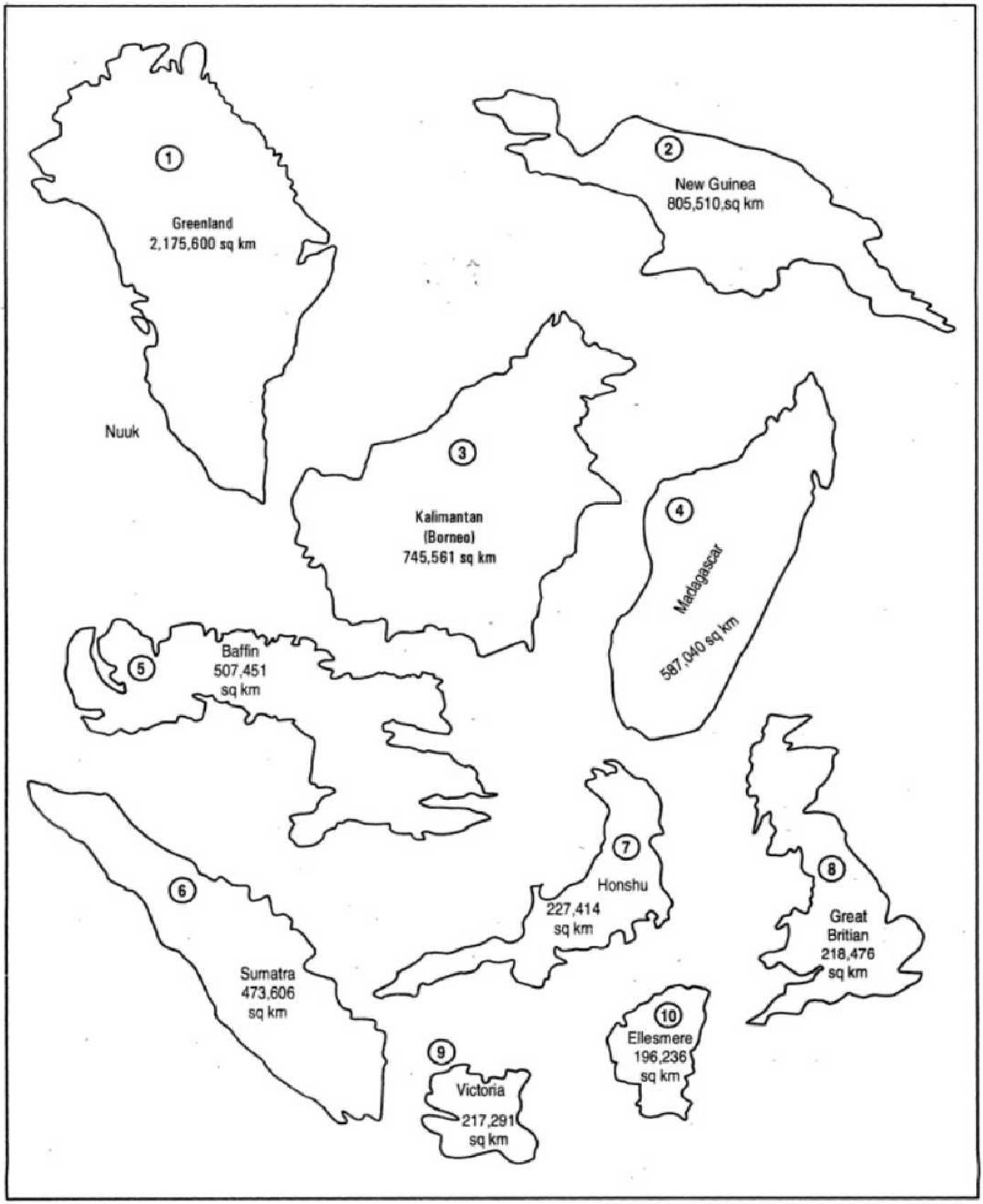

Fig. 6.12 – Major islands of the world

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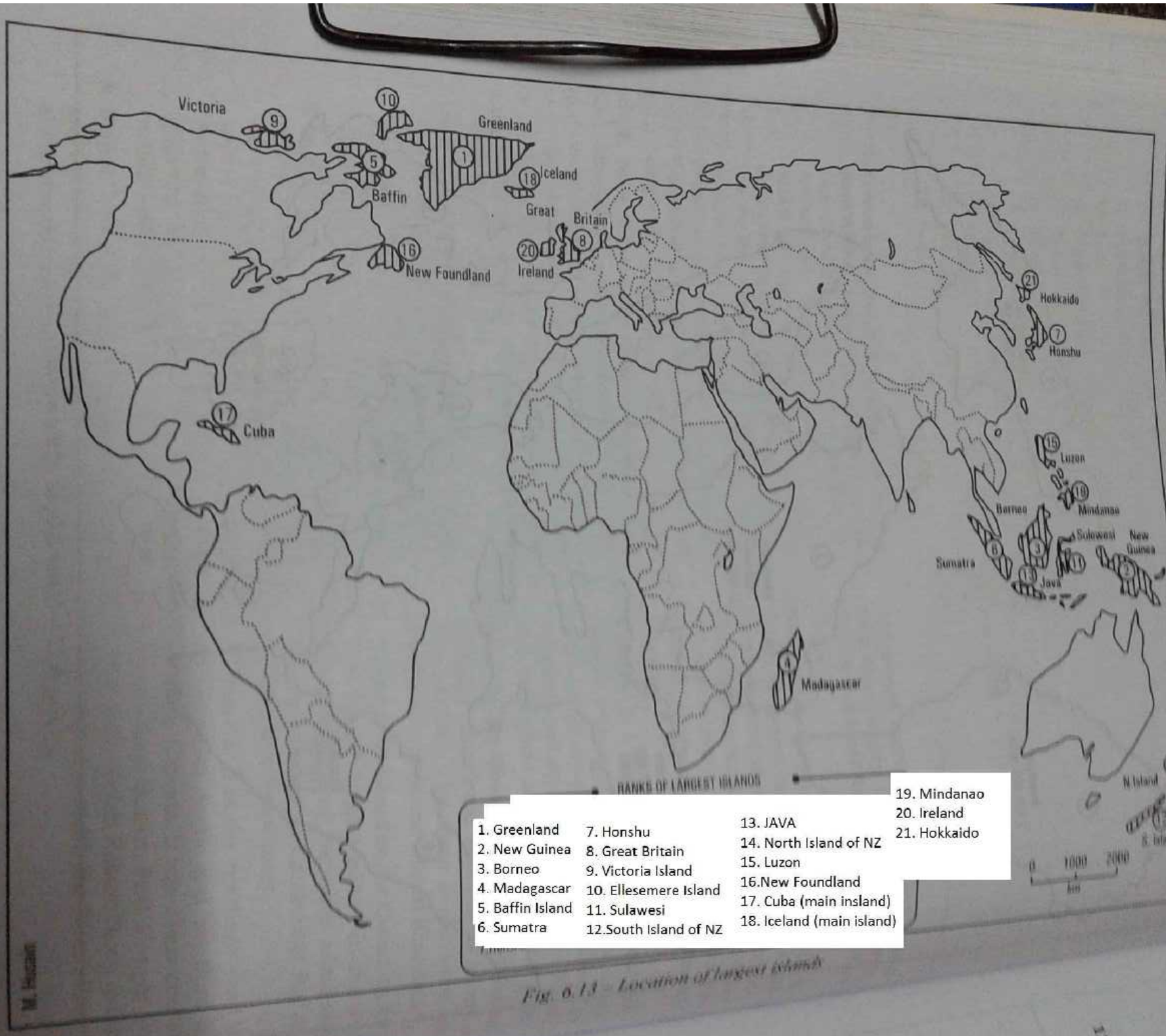

Fig. 6.13 – Location of largest islands

11. **Sulwasi**: Formerly known as Celebes, it is one of the four large islands of Indonesia. It is situated between Borneo and Maluku islands. In Indonesia, only Sumatra, Borneo, and Papua are larger in territory **(Fig.6.13)**.

12. **South New Zealand**: Lying in the south Pacific, it is the largest island of New Zealand. It is dominated by the Southern Alps which stretch along its western coast and rise to 3764 m at Mt. Cook, New Zealand's highest peak. It was sighted by the Dutch navigator Tasman in 1642, and named after the Netherlands province of Zeeland **(Fig. 6.13)**.

13. **Java**: It is an island of Indonesia. With a population of about 137 million, it is the most populous island of the world. It is the home of to 60 per cent of Indonesia's population. Jakarta, the capital of Indonesia is located along the west Java. Formed mostly as the result of volcanic events, Java is the thirteenth largest island in the world and the 5th largest island in Indonesia. Its highest elevation (Semeru) is 3676 m.

14. **North Island of New Zealand**: Lying in the South Pacific, it is the second largest island of New Zealand. Active volcanism occurs in the central region of North Island, with many hot springs, and geysers.

15. **Luzon**: It is the largest and economically and politically important island of Philippines. Manila, the capital of Philippines, is located on this island.

16. **Newfoundland**: The 16th largest island in the world, Newfoundland lies at the mouth St. Lawrence River, Canada. It was explored by John Cabot in 1497. It is a former colony of United Kingdom. It became the tenth province to the Confederation on 31st March, 1949, named simply as Newfoundland.

17. **Cuba**: Cuba, the largest island of Antilles, lies in the Caribbean Sea has a rainy, tropical climate. Sugarcane is the main crop of Cuba which occupies about 60 per cent of the cultivated land.

    Cubans call themselves 'Afro–Latin-Americans. Population of mixed descent (Mulattos) is 51 per cent, whites 37 per cent and blacks 11 per cent. Spanish is the main language. Havana, the capital and largest city of Cuba, is located on this island.

18. **Iceland**: Located between the North Atlantic and the Arctic Ocean, Iceland is an enormous plateau with an average altitude of 500 metres. Reykjavik is the capital and primate city of the country. About 96 per cent of Icelanders are the descendants of Norwegian, Scottish and Irish immigrants and are Protestants by faith.

19. **Mindanao**: It is the second largest and easternmost island of Philippines. The island of Mindanao is called ***The Land of Promise***. Mindanao is the only area of Philippines with a significant Muslim population. A guerrilla war is ongoing on this island.

20. **Ireland**: An island of the British Isles lying west of Great Britain. Four – fifths of it is occupied by the Irish Republic, and remainder by Northern Ireland. Its economy rely heavily on agriculture, especially beef production and dairy farming, settled by Celts. Most of the people are Christians by faith.

21. **Hokkaido**: Formerly known as *Ezo* or *Yezo*, it is the second largest island of Japan. The Tsugaru Starit separates Hokkaido from Honshu, although the two islands are connected by the underwater railway

    Seikan Tunnel: Sapporo is the capital and largest city of Hokkaido.

    Major Lakes: The major lakes and their area have been shown in **Fig. 6.14** while **Table 6.19** shows their ranks and areas.

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Table 6.19:** Largest Lakes of the World in Descending Order of Area **(Fig.6.14)

	Lake	*Area in sq km*
1.	Caspian Sea, Asia and Europe	371,000
2.	Superior, North America	82,103
3.	Victoria, Africa	69,484
4.	Huron, North America	59,570
5.	Michgan (U.S.A.), North America	57,760
6.	Tanganyika, Africa	32,900
7.	Baikal, Asia	31,499
8.	Great Bear, North America	31,328
9.	Nayasa (Malawi), Africa	28,749
10.	Great Slave, North America	28,568
11.	Aral Sea, Asia	28,500
12.	Erie, North America	25,670
13.	Winnipeg, North America	24,387
14.	Ontario, North America	18,960
15.	Ladoga, (Russia) Europe	17,703
16.	Balkash, Asia	17,275
17.	Chad, Africa	16,300
18.	Maracaibo, South America	13,512
19.	Onega, (Russia), Europe	9,700
20.	Eyre, Australia	8,900

Source: **The Nystrom Desk Atlas**, *2008*, p.2, Nystrom Heff Jones Education Division.

1. **Caspian**: A landlocked salt lake closed by Russia, Kazakhstan, Turkmenistan, Azerbaijan, and Iran. It is the world's largest body of inland water with an area of 371,000 sq km. Its northern coast lies 28 m below sea level.
2. **Superior**: It is one of the five great lakes of North America. Superior is the largest fresh water lake in the world. Its area is 82,103 sq km. It is shared by Canada and USA.
3. **Victoria**: It is the largest lake in Africa and the third largest in the world. Its area is 69,484 sq km It is surrounded by Uganda, Tanzania and Kenya.
4. **Huron**: It is the second largest of the five Great Lakes of North America and the fourth largest in the world. Its area is 59,570 sq km.
5. **Michigan**: With an area of 57,760 sq km, it is the fifth largest lake in the world. It is linked to Lake Huron by the Strait of Mackinac.
6. **Tanganyika**: Surrounded by Tanzania, Zaire, Zambia and Burundi, Tanganyika is a lake of east Africa. Its total area is 32,900 sq km
7. **Baikal**: Lying in Siberia, it is the deepest lake in the world. Its area is 31,499 sq km. and depth 1743 m.

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1. Caspian Sea 82,103 sq. km.	2. Superior 82,103 sq. km	3. Victoria 69,484 sq. km	4. Huron 59,570 sq. km.
5. Michigan 57,760 sq. km.	6. Tanganyka 32,900 sq. km.	7. Baikal 31, 499 sq. km.	8. Great Bear 31,328 sq. km.
9. Nayasa (Malawi) 28,749 sq. km.	10. Great Slave 28,568 sq. km.	11. Aral Sea 28,500 sq. km.	12. Erie 25, 670 sq. km.
13. Winnipeg 24,387 sq. km.	14. Ontario 18,960 sq. km.	15. Ladoga 17,703 sq. km.	16. Balkash 17,275 sq. km.
17. Chad 16,300 sq. km	18. Maracaibo 13,572 sq. km.	19. Onega 9,700 sq. km	20. Eyre 8,900 sq. km.

Fig. 6.14 – Largest lakes of the world

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8. **Great Bear**: It is a great lake in the north-west territory of Canada. It is the largest lake in Canada. Its area is 31,328 sq km. It drains into the Mackenzie river via the Great Bear River.
9. **Nayasa (Malawi Lake)**: Surrounded by Tanzania, Malawi and Mozambique, it is one of the deepest lakes of south-east Africa. Its area is about 28,749 sq km.
10. **Great Slave**: It lies in the north-western territory of Canada. It is the deepest lake (615 m) in North America. Named after the slave Indians who used to live on its shores, it is the tenth largest lake in the world.
11. **Aral Sea**: Surrounded in Kazakhstan and Uzbekistan, Aral sea is an important lake of Central Asia. Its area is about 28,500 sq km. The diversion for irrigation flowing into Aral Sea led to water level falling by 13 m and the area of the sea being reduced to tow-thirds of its original size.
12. **Erie** : It is the fourth largest and shallowest of the five Great Lakes of North America. Its total area is about 25,670 sq km.
13. **Winnipeg**: Having an area of 24,387 sq km, it is the third largest lake in Canada.
14. **Ontario**: It is the smallest and most easterly of the Great Lakes of North America, lying on the border between Ontario in Canada and New York State.
15. **Ladoga**: It is a large lake in north-west Russia, north-east of St. Petersburg, near the border with Finland. It is the largest lake in Europe with an area of 17,703 sq km.
16. **Balkash**: It is shallow salt lake with no outlet in Kazakhstan. Its area is 17,275 sq km. It is fed by the River Ili which descends from the Tien-Shan Mountain. It is shrinking in size owing to the use of water for irrigation purpose.
17. **Chad**: It is a shallow lake on the frontiers of Chad, Niger and Nigeria in north-central Africa. Its size varies seasonally from 10,360 sq km to25,900 sq km.
18. **Marcaibo**:With an area of 13,512 sq km, it is linked by a narrow channel to the Gulf of Venezuela and the Caribbean Sea. Over 70 per cent of Venezuela's oil output comes from the lake area. It is a large lake in north-west Venezuela.
19. **Onega**: It is a lake in north-west Russia, near the border with Finland, the second largest lake in Europe. Its area is about 9,700 sq km.
20. **Eyre**: It is a lake of South Australia, named after E.J. Eyre who explored the interior of Australia in 1840. Its area is about 8,900 sq. km. Its size varies seasonally.

Ocean Trenches

Trench is a subduction zone, where two plates converge and one slab of the lithosphere plunges down into the mantle. Trenches, some of which reach over 11,000 m below the sea level are the deepest parts of oceans. A relatively steep slope lies on the leeward side, along the continental landmass, and a more gentle slope lies on the side of the ocean basin. Some of the important ocean trenches described below are shown in **Fig. 6.15**.

Table 6.20:** Ocean Trenches **(Fig.6.15)

	Trench/Ocean	*Depth in metres*
1.	Mariana Trench, Pacific Ocean	11022
2.	Tonga Trench, Pacific Ocean	10882
3.	Japan Trench, Pacific Ocean	10554
4.	Kuril Trench, Pacific Ocean	10542
5.	Mindanao Trench, Pacific Ocean	10497
6.	Kermadec Trench, Pacific Ocean	10047

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7.	Puerto Rico, Atlantic Ocean	9220
8.	Peru-Chile Trench, Pacific Ocean	8050
9.	Aleutian Trench, Pacific Ocean	7822
10.	Cayman Trench, Atlantic Ocean	7680
11.	Java Trench, India Ocean	7450

1. **Mariana Trench**: Situated to the south east of Mariana Island, it is the deepest ocean trench in the world. Its greatest depth is 11,034 m and width about 70 km. Its bottom was reached in 1960 by the US Bathyscape Trieste. The bottom temperature of the trench remains around 2° C.
2. **Tonga Trench**: The Tonga Trench lies to the east of Fiji and south of Samoa in the South Pacific Ocean. Having a depth of 10,882 m, it is the steepest trench in the world. Its eastern side has an angle of about 45°.
3. **Japan Trench**: Having a depth of 10,554 m, the Japan trench lies to the east of Honshu Island at a distance of about 300 km. It has a north south alongation and the maximum width is in the southern side.
4. **Kuril Trench**: Stretching to the east of Kuril Island from north to south, it is one of the deepest ocean trenches of the world. Its depth is 10,542 m.
5. **Mindanao Trench:** This trench lies to the east of Mindanao Island of Philippines. Its depth is 10,497 m.
6. **Kermadec Trench**: Lying in the vicinity of Tonga Trench, its depth is 10,047 m. It is one of the steepest ocean trenches in the world.
7. **Puerto Rico Trench**: Stretching in an east-west direction, it is the deepest trench of the Atlantic Ocean. It lies to the north of Puerto Rico. Its depth is 9,220 m below the sea level. The temperature of the bottom part of the trench is about 3°C.
8. **Peru Trench**: Lying along the western coast of Peru (South America), it is 8,050 m deep.
9. **Aleutian Trench**: Lying to the south of the chain of Aleutian Islands in the North Pacific, it is one of the deepest ocean trenches in the world. Its depth is 7,822 m. The neighbouring areas of the trench have several active volcanoes.
10. **Cayman Trench**: Having a depth of 7,680 m, it lies in the Pacific Ocean.
11. **Java Trench:** It lies to the south of Java Island (Indonesia) in the India Ocean. Its depth is 7450 m.

Table 6.21: Main Gulfs of the World (Fig. 6.16)

Gulf	*Connecting water-body*	*Country*
Gulf of Aden	Arabian Sea (Indian Ocean)	Yemen
Gulf of Alaska	Pacific Ocean	Canada and USA
Gulf of Amundsen	Beaufort Sea (Arctic Ocean)	Canada
Gulf of Aqabah (Aqba)	Red Sea	Egypt and Israel
Gulf of Bo Hai	Yellow Sea (Pacific Ocean)	China
Gulf of Bothnia	Baltic Sea	Sweden and Finland
Gulf of California	Pacific Ocean	Mexico
Gulf of Carpentaria	Arafura Sea, (Indian Ocean)	Australia
Gulf of Darien	Caribbean Sea (Atlantic Ocean)	Panama and Venezuela
Gulf of Gabes	Mediterranean Sea	Libya and Tunisia
Gulf of Guayaquil	Pacific Ocean	Ecuador and Peru

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Gulf of Joseph Bonaparte	Indian Ocean	Western Australia
Gulf of Kachchh (Kutch)	Arabian Sea (Indian Ocean)	India
Gulf of Khambat (Cambay)	Arabian Sea (Indian Ocean)	India
Gulf of Honduras	Caribbean Sea (Atlantic Ocean)	Mexico
Gulf of Lyons	Mediterranean Sea	France and Spain
Gulf of Mannar	Indian Ocean	India and Sri Lanka
Gulf of Martaban	Bay of Bengal (Indian Ocean)	Myanmar
Gulf of Mexico	Atlantic Ocean	Mexico and USA
Gulf of Oman	Arabian Sea	Oman and Iran
Gulf of Panama	Pacific Ocean	Panama
Gulf of Papua	Coral Sea	South Atlantic Ocean
Gulf of Persia	Arabian Sea (Indian Ocean)	Iran, Kuwait, Oman, Qatar, Saudi Arabia, UAE
Gulf of Riga	Baltic Sea	Estonia and Latvia
Gulf of San Jorge	South Atlantic Ocean	Argentina
Gulf of San Matias	South Atlantic Ocean	Argentina
Gulf of Sirte	Mediterranean Sea	Libya
Gulf of St. Lawrence	North Atlantic Ocean	Canada
Gulf of Tatary	Sea of Japan (Pacific Ocean)	Russia
Gulf of Thailand	Pacific Ocean	Thailand and Cambodia
Gulf of Tonkin	South China Sea (Pacific Ocean)	China and Vietnam

Table 6.22**: Main Capes of the World **(Fig. 6.17)

Cape	*Country*	*Important Town*	*Ocean/Sea*	*Location*
Agulhas, Cape	South Africa	Agulhas	Indian Ocean	Indian Ocean
Blanco, Cape	U.S.A.	Port Orford	Pacific Ocean	State of Oregon, Pacific Ocean
Canaveral, Cape	U.S.A.	Cape Canaveral	Atlantic Ocean	Atlantic Ocean
Cancun, Cape	Mexico	Cancun	Gulf of Mexico	North Atlantic Ocean
Chidley, Cape	Canada	Chidley town	Labrador Sea	North-east tip of Labrador Peninsula, North Atlantic Ocean
Cod, Cape	Bay of Massachusetts, N.East, U.S.A.	Bourne	Bay of Funday	North Atlantic Ocean
East, Cape	New Zealand		North Island, New Zealand	Pacific Ocean
Farewell, Cape	Greenland	Labrador Sea	North Atlantic Ocean	Atlantic Ocean

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Faria, Cape	Angola		Atlantic Ocean	Atlantic Ocean
Frio, Cape	Brazil	Frio Panensula		S. Atlantic Ocean
Good Hope, Cape	South Africa	Cape of Good Hope	Atlantic Ocean	Atlantic Ocean
Guardafui, Cape	Somalia	Guuardafui	Arabian Sea	India Ocean
Hatteras, Cape	U.S.A.	Frisco	Atlantic Ocean	Atlantic Ocean
Horn,Cape	Chile	Cape Horn	-	South Atlantic Ocean
Howe, Cape	Australia		New South Wales, Tasman Sea	South Pacific Ocean
Icy, Cape	U.S.A.	Wainwright	Chukchi Sea	
Kanniyakumari (Cape Comorin)	India	Kanniyakumari	Indian Ocean	Indian Ocean
Leeuwin, Cape	Australia		Indian Ocean	Western Austraila
Lucas, Cape San	Mexico	San Lucas	Pacific Ocean	Baja Peninsula, Pacific Ocean
Matapan, Cape	Greece	-	Mediterranean Sea	Greece, Mediterranean Sea
North Cape	New Zealand	-	South Pacific Ocean	Northern Tip of North Island, New Zealand, South Pacific Ocean
North Cape	Norway	-	Norwegian Sea	Arctic Ocean
North-West, Cape	Australia	-	Indian Ocean	Western Australia, Indian Ocean
Orange Cape	Brazil	Pracuba	Atlantic Ocean	Northern-most point of Brazilian State Amapa
Sandy, Cape	Australia			Queensland, Australia, South Pacific Ocean
San Lucas	Mexico	Cabo San Lucas	San Lucas Bay, Pacific Ocean	
St. Francis, Cape	South Africa		Indian Ocean	Indian Ocean
Sao. Roque Cape	Brazil	Ceara-Mirim	Atlantic Ocean	Northernmost point of the Brazilian State of Amapa
Verde, Cape	Senegal	Cape Verde	Dakar North Atlantic Ocean	
Vincent Cape	Portugal			
York, Cape	Australia		Pacific Ocean	

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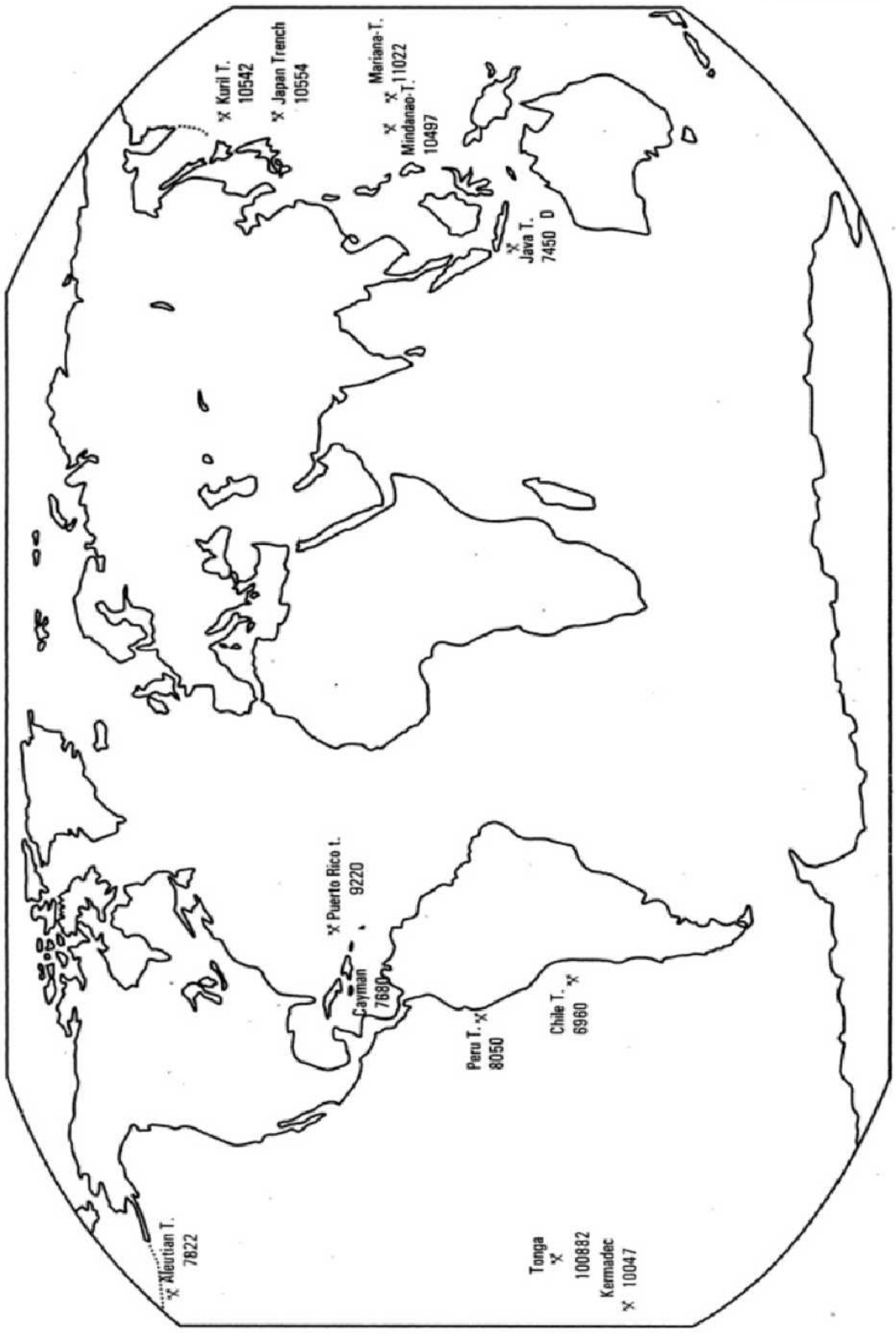

Fig. 6.15 – World – Trenches

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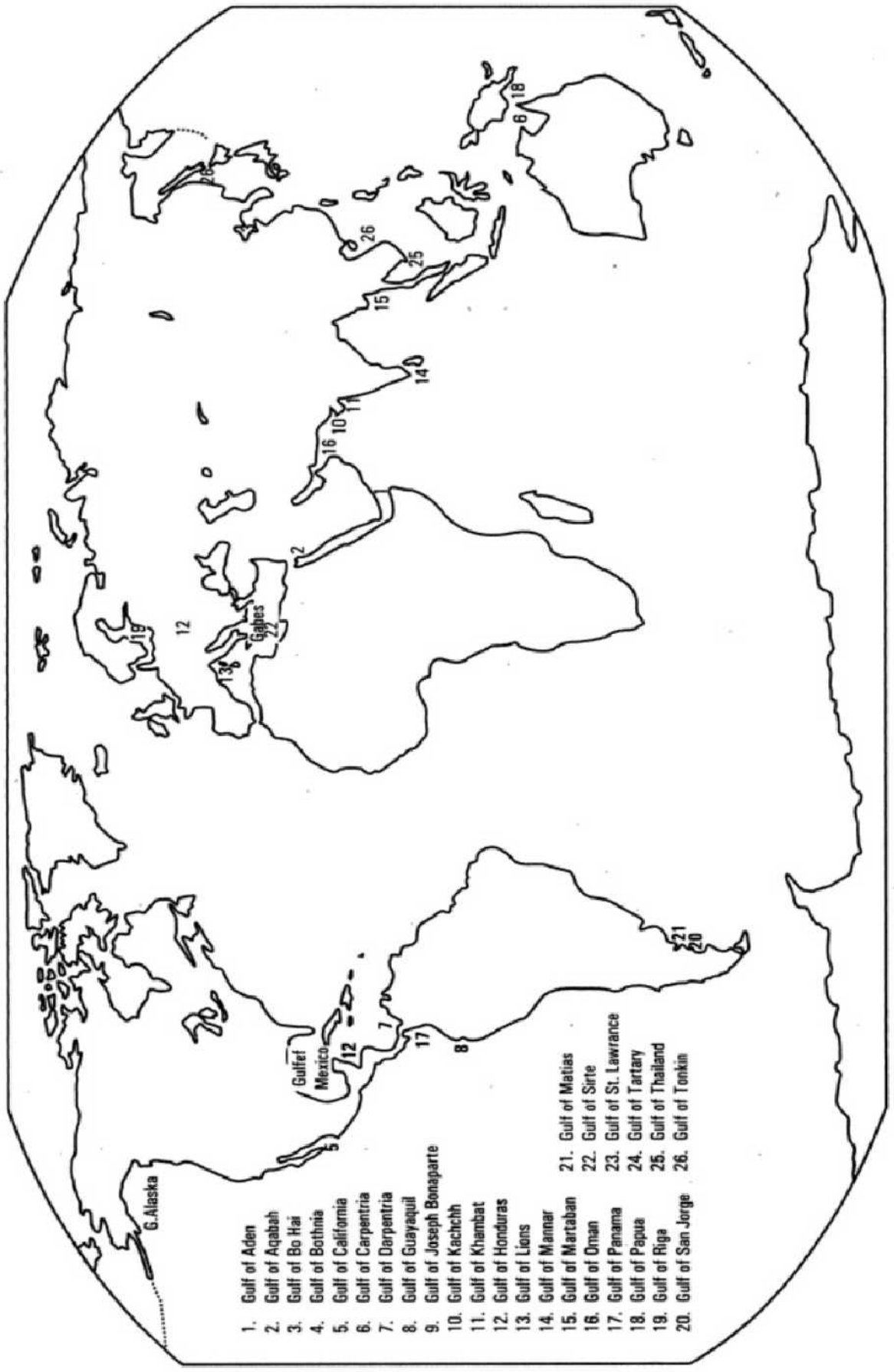

Fig. 6.16- Main gulfs of the world

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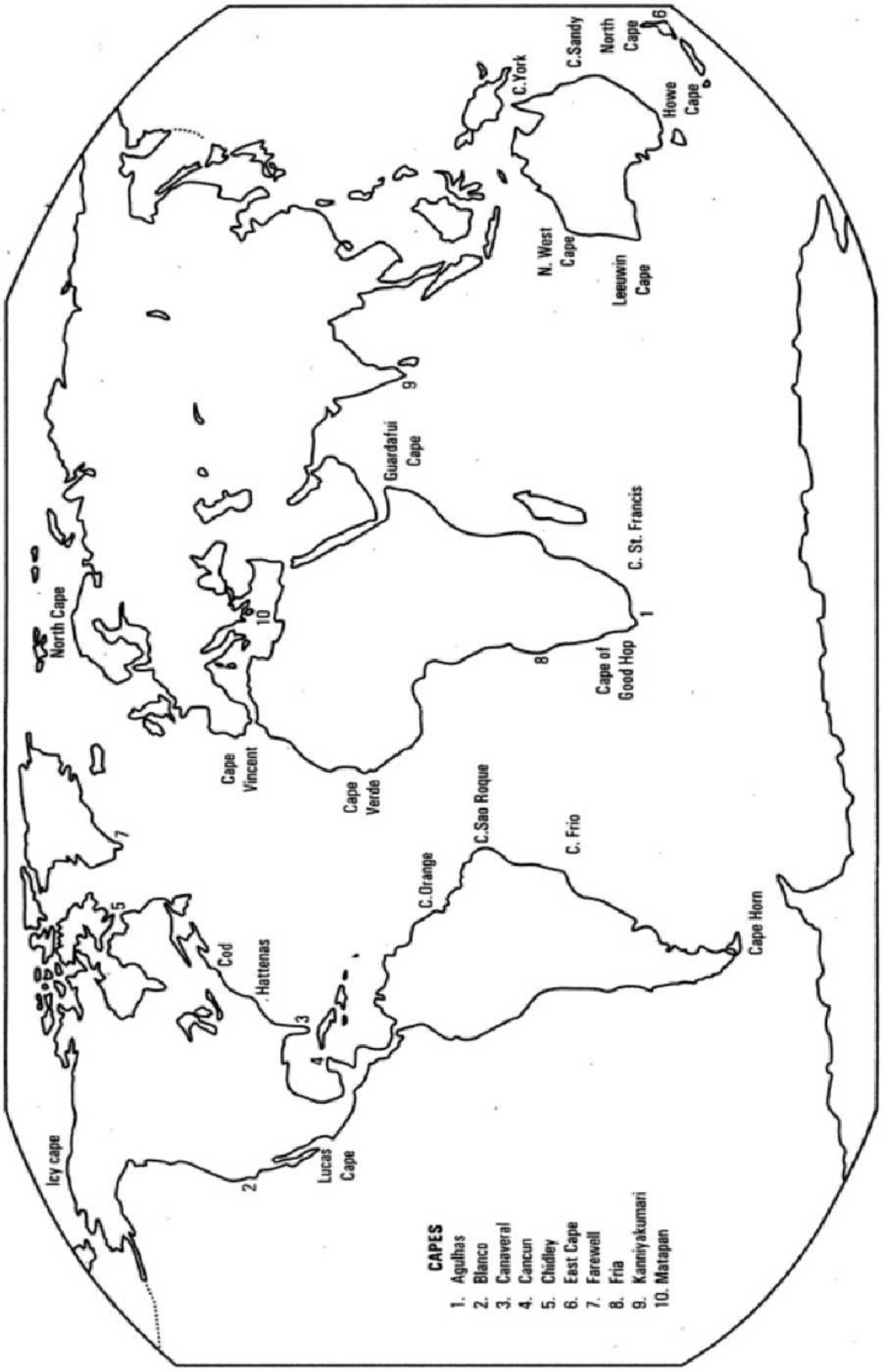

Fig. 6.17- World - Main capes

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Table 6.23: The Highest Waterfalls of the World (Fig.18)

	Waterfall	River	Country	Total height
1.	Angel	Carrao/Caroni/Orinoco	Venezuela	979 m
2.	Tugela	Tugela	Natal province (South Africa)	948 m
3.	Utigord	Jostedal glacier	Norway	826 m
4.	Monge	Monge	Norway	780 m
5.	Mutarozi	Mutarozi	Zimbabwe	762 m
6.	Yosemite	Yosemite	California (U.S.A.)	746 m
7.	Espland	Esplande	Norway	725 m
8.	Mardalsfossen	Mardola River	Norway	705 m
9.	Kukenan(Cuquenan)	Yosemite National Park	Venezuela	670 m
10.	Sutherland	Arthur	New Zealand	580 m
11.	Kjell	Myrdal	Norway	525 m
12.	Ribbon	Yosemite	California	496 m

1. **Angel waterfall**: Located on Karoni River (a tributary of Orinoco River), it is the highest waterfall in the world. It has a straight fall of 978 m. The Angel Waterfall was discovered by a pilot (James Angel) in 1935 after whom the waterfall was named.

2. **Tugela Waterfall**: Located in the Natal Province of South Africa, it is one of the highest waterfalls of the world. Its total height is 948 m.

3. **Utigord (Ramnefjellsfossen) Waterfall**: It is located in Norway. Its fall is 826 m.

4. **Monge (Monge)Waterfall**: It is located on the Rauma River of Norway. Its fall is 780 m.

5. **Mutarozi (Mtarazi) Waterfall**: It lies on the Mtarazi River in the Eastern Highlkands of Zimbabwe. Its height is 762 m.

6. **Yosemite Waterfall**: With height of 746 m, it is the highest measured waterfall in North America.It is located in the Yosemite National Park in the Sierra Nevada of California. It is a major attraction in the park, especially in late spring when the water flow is at its peak.

7. **Espland Waterfall**: Located in Norway, it is one of the highest waterfalls of the world. Its total height is 725 m.

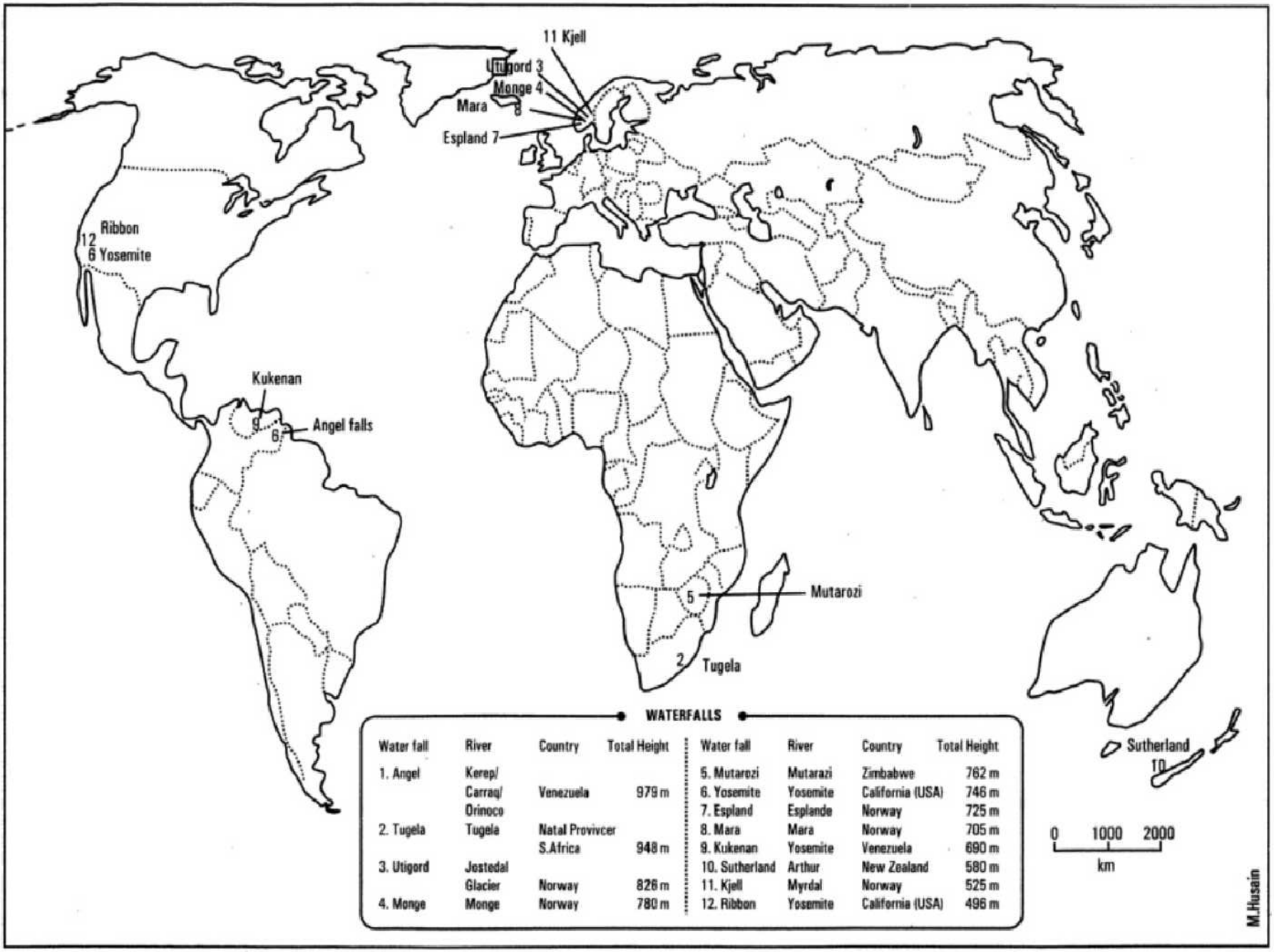
8. **Mardalsfossen Waterfall**: Located in Norway, it is one of the highest waterfalls in Europe. It is on the Mardola River. Its total height is 705 m.

9. **Kukenan (Cuquenan) Waterfall**: It is the second tallest waterfall in Venezuela after Angel Waterfall. The falls drop in a single leap is around 670 m. It is located near Mount Roraima near the border of Brazil, Venezuela and Guyana.

10. **Sutherland Waterfall**: This is a waterfall near Milford in New Zealand's South Island. It has a straight fall of 580 m.

11. **Kjell Waterfall (Kjell Falls):** It is one of the highest waterfalls in Norway. Its total fall height is 755 m.The fall is located near the village of Gudvangen in the municipality of Aurland in Fiordane county.

12. **Ribbon Waterfall**: Located in Yosemite National Park in California, it is the largest single-drop waterfall in North America. The fall is fed by melting winter snow. Consequently, it remains dry for the greater part of the year. Its total fall is 496 m.



WATERFALLS

Water fall	River	Country	Total Height
1. Angel	Kerep/ Carraq/ Orinoco	Venezuela	979 m
2. Tugela	Tugela	Natal Provivcer S.Africa	948 m
3. Utigord	Jostedal Glacier	Norway	826 m
4. Monge	Monge	Norway	780 m
5. Mutarozi	Mutarazi	Zimbabwe	762 m
6. Yosemite	Yosemite	California (USA)	746 m
7. Espland	Esplande	Norway	725 m
8. Mara	Mara	Norway	705 m
9. Kukenan	Yosemite	Venezuela	690 m
10. Sutherland	Arthur	New Zealand	580 m
11. Kjell	Myrdal	Norway	525 m
12. Ribbon	Yosemite	California (USA)	496 m

Fig. 6.18 – World – Highest waterfalls

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Highest Dams of the World

Dam is a structure built across a river in order to restrain or use of water. A large number of dams have been constructed in the world. The first ten highest dams in the world have been given in **Table 6.24.**

***Table 6.24:** World–Major Dams* **(Fig. 6.19)**

	Dam	*River*	*Country*	*Height in metres*
1.	Nurek Dam	Vakhsh	Tajikistan	317
2.	Grand Dixence Dam	Dixence	Switzerland	285
3.	Vajont Dam	Vajont	Italy	262
4.	Oroville Dam	Feather	California (U.S.A.)	235
5.	Bhakra-Nangal Dam	Satluj	India	226
6.	Hoover Dam	Colorado	U.S.A.	221
7.	Kurobegwa Dam	Kurobe	Japan	186
8.	Cahora-Bassa Dam	Zembezi	Zimbabwe	171
9.	Akosombo Dam	Volta	Ghana	141
10.	Warragamba Dam	Warrangamba	Australia	137

1. **Nurek Dam (Tajikistan)**: It is an earth filled dam on *Vakhsh* River in the central Asian republic of Tajikistan. Having a height of 317 m, it is the tallest dam in the world. Construction on this dam was started in 1961 and completed in 1980.
2. **The Grande Dixence Dam (Switzerland)**: It is a concrete gravity dam on the Dixence River in Switzerland. Having a height of 285 m, it is the tallest gravity dam in the world. The basic objective of the dam is to produce hydro electricity with a capacity of 2069 MW, enough for 400,000 households. The construction of the dam was started in 1950 while the dam was commissioned in 1965.
3. **The Vajont Dam, or Vaiont Dam (Italy):** Constructed across the Vajont River, about 100 km to the north of Venice in Italy, it is the third highest dam in the world. It was responsible for the deaths of approximately 2000 people in the 1963 landslide. It is 262 m high, 27 m thick at the base and 3.4 m at the top.
4. **Oroville Dam (California, U.S.A.)**: It has been constructed across the Feather River above the city of Oroville, California, United States. It generates electricity and provides drinking and irrigation water for central and southern California.
5. **Bhakra Nangal Dam (Punjab-India)**: It is a concrete gravity dam across the Satluj River, near the border between Punjab and Himachal Pradesh in Northern India. It is a joint venture of the Punjab, Haryana and Rajasthan governments. The dam located in the village of Bhakra in the Bilaspur region of Himachal Pradesh, is one of the highest dams in Asia. Its height is 226 m. The length of the dam is 518 m and width at the top 9 m. The dam attracts tourists from all over India throughout the year.
6. **Hoover Dam-Boulder Dam (U.S.A.)**: It is a concrete arch-gravity dam in the Black Canyon of the Colorado River on the border of Arizona and Nevada states of U.S.A. When completed in 1935, it was both the world's largest hydroelectric power generating station and the world's largest concrete structure. It has been named after President Herbert Hoover, who played a vital role in its construction. Lake Mead is the reservoir created by the dam, named after Elwood Mead, who supervised the construction of the dam.

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7. **The Kurobe Dam (Japan):** Constructed across the Kurobe River (Honshu Island), it is the largest dam of Japan. It is 186 m in height. Its construction was completed in 1963. It generates electricity for Kansai Electric Power Company.
8. **The Cahora Bassa (Zimbabwe):** Constructed across the Zembizi River, it is one of the largest dams in Africa. Its height is 171 m. It is one of the three major dams on the Zambezi River, the others being Kariba and Itezhi Tezhi. The project was commissioned in 1969. The lake (reservoir)has a maximum length and width of approximately 250 km and 38 km, respectively. The installed capacity of the project is 2075 MW.
9. **The Akosombo Dam (Ghana):** It is hydro-electricity dam in southern Ghana across the Volta River. The primary purpose of the Akosombo Dam was to provide electricity for the aluminium industry. The flooding to create the lake Volta Reservoir, displaced many people and had a significant impact on the environment of the region.
10. **Warragamba Dam (Australia):** It is the primary water source for the Australian city of Sydney. It is approximately 65 km to the west of Sydney on the Warragamba River, a tributary of the Hawkesbury River.

Mega Cities of the World

According to the Population Division of UNO, a city having a population of 8 million or more is called as a mega-city. The mega cities of the world have been shown in **Fig. 6.20 (Table 6.25).**

Table 6.25:** World – Mega–cities (Population over 8 million) **(Fig. 6.20)

	City and Country	*Population actual in 2005*	*Population projected for 2015*
1.	Tokyo Japan	35,197,000	35,494,000
2.	Mexico City, Mexico	19,411,000	21,568,000
3.	New York, United States	18,718,000	19,876,000
4.	Sao Paulo, Brazil	18,333,000	20,535,000
5.	Mumbai (Bombay), India	18,855,000	20,854,000
6.	Delhi, India	16,854,000	18,900,000
7.	Shanghai, China	14,503,000	17,225,000
8.	Kolkata (Calcutta), India	16,567,000	18,653,000
9.	Jakarta, Indonesia	13,215,000	16,822,000
10.	Buenos Aires, Argentina	12,550,000	13,396,000
11.	Dhaka, Bangladesh	12,430,000	16,842,000
12.	Los Angles, United States	12,298,000	13,095,000
13.	Karachi, Pakistan	11,608,000	15,155,000
14.	Rio de Janeiro, Brazil	11,469,000	12,770,000
15.	Osaka-Kobe, Japan	11,268,000	11,309,000
16.	Cairo, Egypt	11,128,000	13,138,000
17.	Lagos, Nigeria	10,886,000	16,141,000
18.	Beijing, China	10,717,000	12,850,000
19.	Manila, Philippines	10,686,000	12,917,000
20.	Moscow (Russia)	10,654,000	11,022,000
21.	Paris (France)	9,535,000	10,000,000

Source: **The Nystrom Desk Atalas**, *2008*, p.2, Nystrom Herff Jones Education Division.

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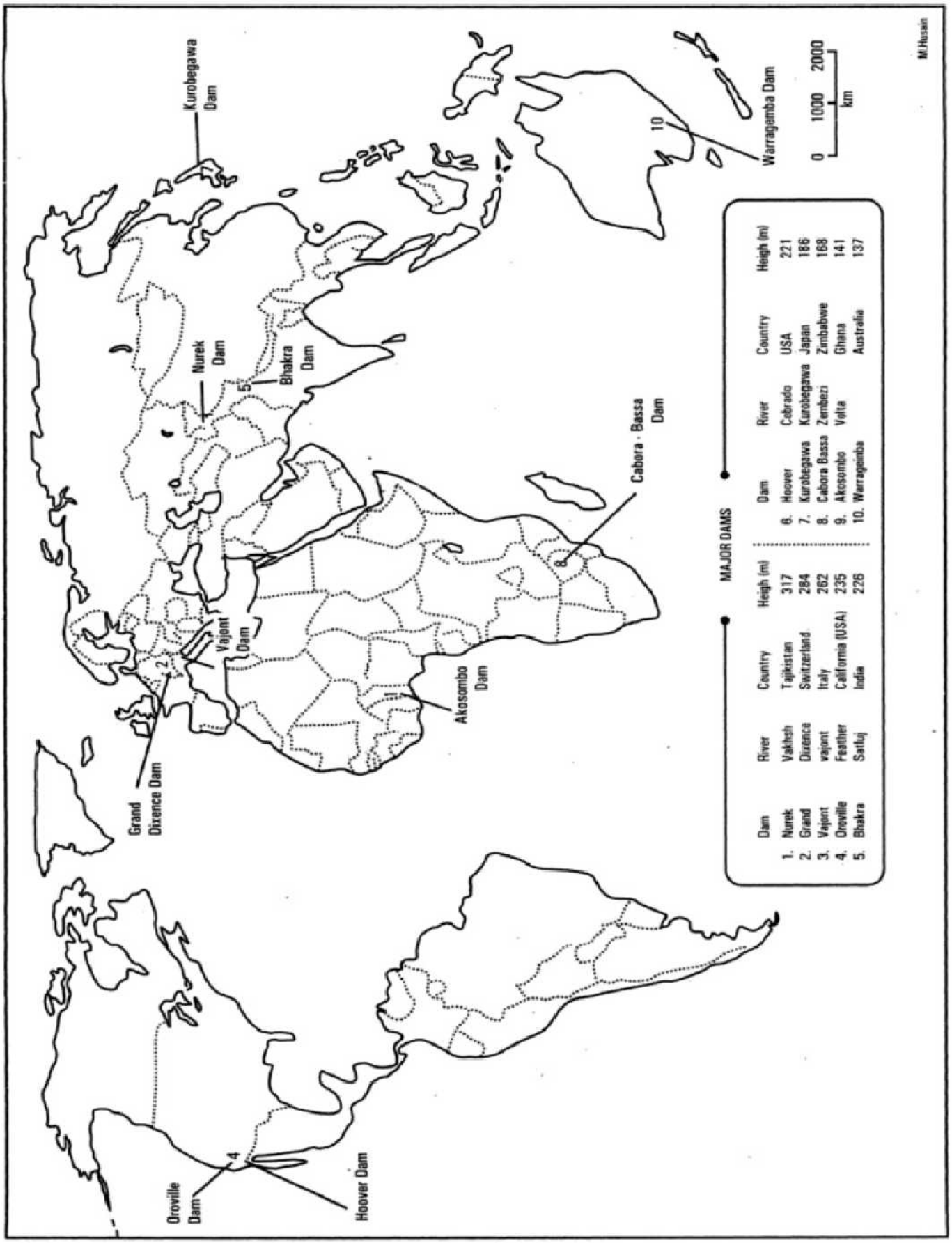

Fig. 6.19 – World – Major dams

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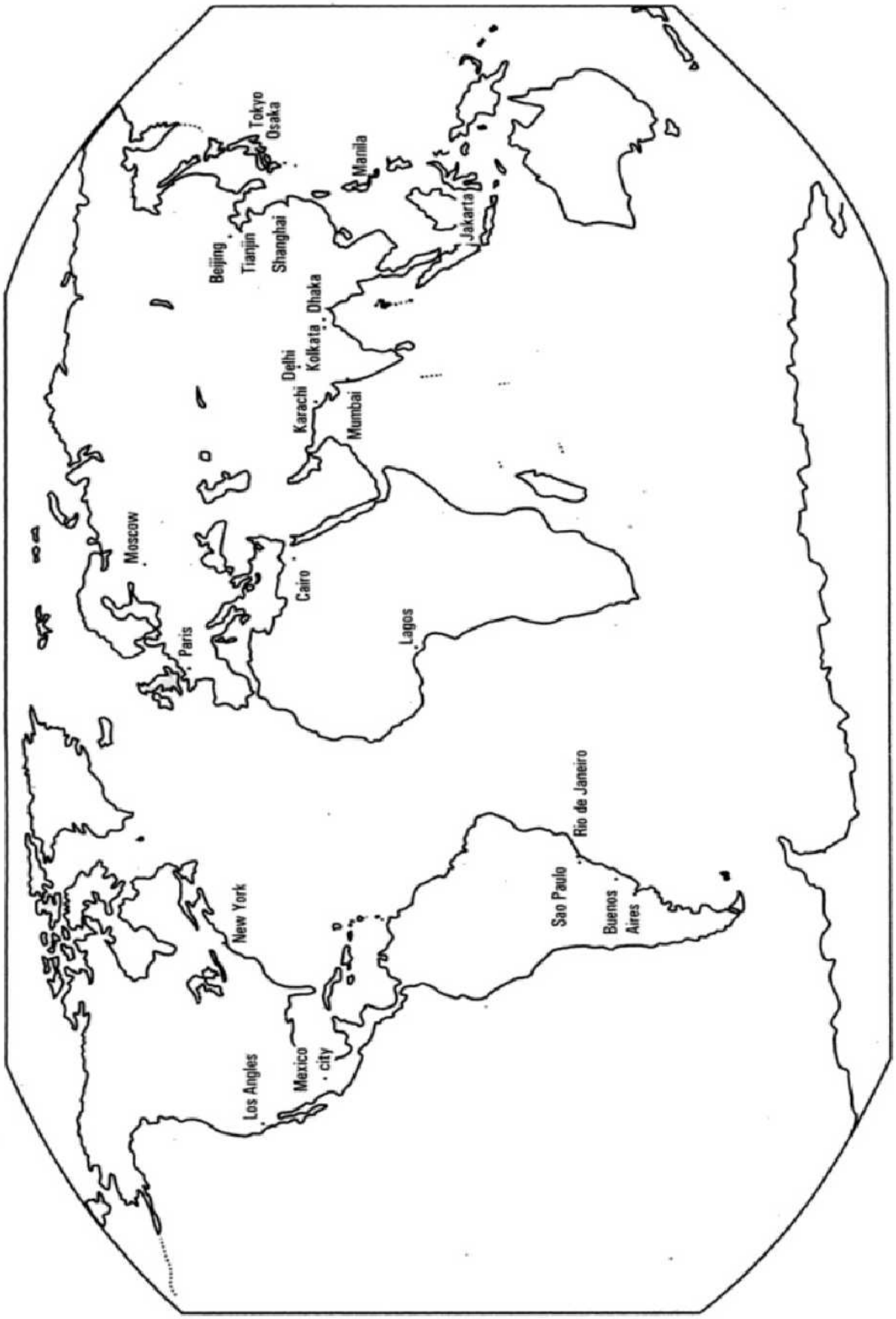

Fig. 6.20 – Mega cites of the world

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1. **Tokyo:** Situated in the Kanto Plain (Honshu Island), it is the capital, cultural and industrial city of Japan and the largest city of the world. Its main industries include iron and steel, chemical, pharmaceutical, machinery, vehicle, electronic goods, optical articles, surgical equipments, printing and publishing and food processing. Its Narita Airport is one of the biggest in the world.
2. **Mexico City**: It is the capital, cultural, political, administrative and commercial centre of Mexico. Having a population of over 19 million, it is the second largest city of the world. Over 40 per cent of its total population is, however, living in slums and shanty colonies. Its main industries include machine tools, engineering goods, chemicals, electronics, printing and food processing.
3. **New York**: It is the commercial capital, largest city and seaport of the United States of America. Its famous skyscrapers include the Empire State Building (381 m). The World Trade Tower (411 m) was destroyed by the suicide attack of Al-Qaida on September 11, 2001. The UNO Headquarters is located in the Manhattan Island of New York. This city has the monument of Statue of Liberty. It has two international airports, namely, Las Guardia and J.F. Kennedy. A large number of tourists visit this city throughout the year.
4. **Sao-Paulo**: Having a population of about 18 million, it is the largest city of Brazil. It is the leading, commercial, industrial and cultural centre of Brazil. Its main industries include coffee processing, automobiles, machinery, electronics, electric goods, and agricultural equipment. It has the largest coffee market in the world.
5. **Mumbai (Bombay)**: (Population 18,855,000) The largest city and commercial capital of India is one of the largest seaports and industrial centre of India. Its main industries include textiles, engineering, automobiles, petrochemical, pharmaceutical, films, ceramics, electronic goods, consumer goods and food processing. Its Gateway of India, Church-Gate, Malabar Hills, Marine Drive, and Taj Hotel are famous all over the world.
6. **Delhi:** (Population 16,854,000) Situated along the banks of Yamuna, Delhi is a historical cosmopolitan city of India. Old Delhi is known as Shahjahanabad in which the historical monuments of Red Fort and Jama-Masjid are located. Indraprastha, Purana Qila, Qutab Minar, Humayun's Tomb, and India Gate are the other important historical buildings of the city.
7. **Shanghai**: It is the largest city, industrial centre and seaport of China. The main industries of Shanghai include ship-building, textiles, oil-refinery, electronics, light machinery and consumer goods.
8. **Kolkata (Calcutta):** (Population 16,567,000) Situated along the banks of Hugli River, Kolkata is the capital of West Bengal. Founded in 1690 by the East India Company, it was the capital of British India from 1833 until 1912 when it was replaced by New Delhi. Its historical buildings include Fort William, High Court, and Government House. Cotton and jute textiles, chemichals, automobiles, pharmaceutical, electric goods and consumer items are the main industries of the city.
9. **Jakarta**: Situated in Java, it is the capital, largest city and cultural centre of Indonesia. It is one of the most densely populated countries of the world. Its main industries include ship-building, textiles, chemicals, automobiles, engineering and consumer goods.
10. **Buenos Aires:** Located on the south bank of River Plate. Its industries include automobiles, it is the capital city, commercial, industrial and cultural centre of Argentina. Its main industries include engineering, oil, chemicals, textiles, paper and food processing. It is a major cultural centre with several universities. The

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National Library and a world-famous opera house are located in this city.

11. **Dhaka**: Located on the Delta of Padma and Meghna, it is the capital of Bangladesh. The city has a striking mixture of architectural styles. Its impressive buildings include the Lal Bagh Fort, and several mosques. Much of the city is low-lying and subject to flooding. Its main industries include textiles, jute textiles, engineering goods, automobiles and consumer goods.

12. **Los Angles**: Located at the Pacific coast, it is the second largest city of U.S.A. It is known for automobile, pharmaceutical, film industry, oil-refining, and consumer goods. Smog pollution is the main problem of the city. It is also cultural and tourist centre.

13. **Karachi**: Karachi is a major industrial, commercial and financial city and a port in Pakistan. Situated on the Arabian Sea near the mouth of the Indus river, it was the capital of Pakistan (1947-59) before being replaced by Islamabad. Muhammad Ali Jinnah, father of Pakistan was born here in 1876. Karachi has heavy industries including automobile assembly, oil refining, steel, ship-building, as well as textile, printing, processing, chemical and engineering industries.

14. **Rio de Janeiro**: Situated along the Atlantic coast, it is the former capital and second largest city of Brazil after Sao-Paulo. It is the cultural and financial capital of the country. Its buildings range from beautiful churches to famous modern architecture which contrast with the huge shanty-towns of *favelas*. The capital was eventually transferred to Brasilia in 1960.

15. **Osaka**: It is a port, commercial, and cultural city in Honshu Island of Japan. It is a natural harbour and the third largest city of Japan. It is also known as the Manchester of the East.

16. **Cairo**: It is the capital and cultural centre of Egypt. Situated on the delta of Nile river, it is the largest city in the continent of Africa. It was founded by the Fatamid Dynasty in 969. Cairo's mosques include *Al-Azhar*, which houses an Islamic University said to be the oldest in the world and the leading centre of Islamic education. Cairo has many light industries including tourism.

17. **Lagos**: Situated on the Gulf of Guinea, it is the main city and cultural centre of Nigeria. Its overcrowded slums contrast with modern developments and its traffic congestion is notorious. It has many light industries and craft products.

18. **Beijing (Peking)**: It is the capital of China. It was developed from the Kublai Khan's capital built in the late 13th century. Tianamen Square outside the Forbidden City was the scene of demonstration in June 1989. Beijing is the political, cultural, financial, educational and transportation centre of China. It is also the major industrial centre with iron and steel, textiles, chemical plants and numerous heavy and light industries.

19. **Manila**: It is the capital, cultural centre and main seaport of Philippines. Its industries include automobile assembly, metallurgical, chemical, and textile industries as well as light industries such as food processing and pharmaceuticals.

20. **Moscow (Moskva)**: Situated on the banks of Moskava River, it is the capital and largest city of Russia. Its famous monuments include Kremlin, Bolshoi Ballet. Its industries include iron and steel, machinery, automobile and light industries.

21. **Paris**: Situated on the banks of Seine River, it is the capital and cultural centre of France. Its main industries include luxury goods, perfumes, jewellery, automobiles, trucks, light machinery, and food processing. Its Eiffel Tower (1889) and Pompidou Centres are great attrtaction for the tourists. Paris is the transport and communication focus of western Europe with three international airports and seven main railway stations.

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Table 6.26: Continents, Area, Population, No. of Countries, Highest Points, Lowest Points

Continent	Area (sq km)	Estimated population (in thousand)	No. of Countries	Highest point	Lowest point
Asia	44,579,000	3,679,737	47	Mount Everest, Tibet/Nepal 8850 m	Dead Sea -392 m bsl
Africa	30,065,000	795,671	53	Mt. Kilimanjaro (Tanzania)	Lake Assal 156 m bsl
North America	24,256,000	315,915	23	Mt. McKinley (Alaska) 6194 m	Death Valley 86 m bsl
South America	17,819,000	349,510	12	Mt. Aconcagua (Argentina)- 6960 m	Valdes Peninsula 40 mbsl
Europe	9,938,000	727,986	43	Elbrus-Russia/ Georgia, 5642 m	Caspian sea 28 m bsl
Oceania	7,687,000	31,043	14	Kosciusko, 2228 m	Lake Eyre, 16 m bsl
Antarctica	13,209,000	0	0	Vinson Massif Ellsworth Mountain, 5140m	2,538 m bsl

Source: **Oxford Student Atlas for India**, 2004, Oxford University Press.

Table 6.27: Temperature Extremes

	Continent	Location	Dates	Temperature
1.	Africa	Al-Aziziya, Libya	13th Sept., 1922	58°C
2.	North America	Deatyh Valley, US	10th July, 1913	55.7°C
3.	Asia	Tirat Tsvi, Palestine, Israel	21 June, 1942	53.9°C
4.	Oceania	Cloncurry, Australia	16th Jan., 1889	53.3°C
5.	Europe	Seville, Spain	4th August, 1881	50.0° C
6.	South America	Rivadavia, Argentina	11 Dec., 1905	48.9°C
7.	Antarctica	Vanda Station, Scott Coast	5th June, 1974	15°C

Source: Husain, M, 2009 **Fundamentals of Physical Geography**, Jaipur, Rawat Publications.

Table 6.28: Coldest Places (Lowest Temperatures) – Continent-wise

	Continent	Location	Date	Temperature
1.	Antarctica	Vostok Station	21 July, 1983	-88° C
2.	Asia	Verkhoyansk, Siberia	7th Feb., 1892	-69°C
3.	North America	Northice Greenland	9th Jan., 1954	-66°C
4.	Europe	Ust-Shchuger, Russian Fed.	Not known	-55°C
5.	South America	Sarmiento, Argentina	Ist June, 1907	-33°C
6.	Africa	Ifrane, Morocco	11th Feb., 1935	-24°C
7.	Oceania	Charlotte Pass, Australia	29th June, 1994	-23°C

Source: Husain, M. 2009, **Fundamentals of Physical Geography**, Jaipur, Rawat Publications.

***Table 6.29:** Wettest Places–Highest Annual Precipitation*

	Continent	*Location*	*Precipitation*
1.	Asia (Meghalaya-India)	Mawysynram	1186 cm
2.	Oceania	Mt. Waialeale, Hawaii	1168 cm
3.	Africa	Debundscha, Cameroon	1029 cm
4.	South America	Quibdo, Colombia	899 cm
5.	North America	Henderson Lake, Canada	650 cm
6.	Europe	Crkvica, Bosnia-Herzegovina	365 cm

Source: **The Illustrated World Atlas**, 2004, p.261, New York, Barnes and Nobles.

***Table 6.30:** Lowest Average Annual Precipitation*

	Continent	*Location*	*Precipitation*
1.	South America	Quillagua	0.05cm
2.	Africa	Wadi Halfa, Sudan	0.25cm
3.	Antarctica	South Pole	2.0cm
4.	North America	Batagues, Mexico	3.1cm
5.	Asia	Aden, Yemen	4.6cm
6.	Oceania	Mulka, Australia	10.4cm
7.	Europe	Australia, Russian Fed.	16.3cm

Source: **The Illustrated World Atlas,** p.261, New York, Barnes and Nobles.

***Table 6.31:** Largest Deserts of the World*

Desert	*Location*	*Sq km*
Sahara	North Africa	9,065,000 (Algeria, Chad, Egypt, Libya, Mali, Mauritania, Morocco, Niger, Sudan, Tunisia,
Gobi	Mongolia/China	1,295,000 (Mongolia, China-Inner Mongolia)
Kalahari	South Africa	582,000 (Botswana)
Namibia	Namibia	3100 sq km
Great Victoria	Australia	338,500
Great Sandy	Australia	338,500
Ruba-al-Khali (Desert of Peninsula of Arabia)	Kuwait, Oman, Saudi Arabia, Syria, UAE, Yemen	1300,000
Other Deserts	Atacama Desert-180,000 sq km (northern Chile), Dasht-e-Lut-52,000 sq km (Eastern Iran), Desert de Sachura-26,000 sq km (southern Peru), Kera-Kum 270,000 sq km (Turkmenistan),	Mojavo Desert-35,000 sq km (Southern California), Namibia Desert-310 sq km (Namibias), Sonoran Desert-310 sq km (Arizona and Mexico), Takla Makan-320 sq km (Sinking Province-China), Thar Desert -260,000 sq km (Western

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	Kyzyl, Kum-180,000 sq km (Uzbekistan and Kazakhstan,)	Rajasthan–India, and Sindh province of Pakistan)

Source: **Oxford Student Atlas for India**, 2004, Oxford University Press and **Rashtraya School Atlas**, Delhi, Indian Book Depot.

Table 6.32: *Ocean Currents*

Currents of the Atlantic Ocean	*Currents of the Pacific Ocean*	*Currents of the Indian Ocean*
North Equatorial Current	North Equatorial Current	North Equatorial Current
Bahama Current	Kuro-Siwo	South Equatorial Current
Gulf Stream	Oya Siwo (Kurile Current)	West Australian Current
Labrador Current	Alaska Current	Agulhas Current
Canary Current	California Current	Somalian Current
North Atlantic Drift	South Equatorial Current	West Wind Drift
South Equatorial Current	Peru Current (Humboldt Current)	
Brazilian Current	East Australian Current	
Benguela Current	Equatorial Counter Current	
South Atlantic Drift		

Table 6.33: *Deadliest Volcanic Eruptions*

Location	*Year*	*Deaths*
1. Tambora, Indonesia	1815	92,000
2. Karakatoa, Indonesia	1883	34,417
3. Mt. Pele, Martinique	1902	29,025
4. Ruiz, Colombia	1985	25,000
5. Unzen, Japan	1792	14,300
6. Laki, Iceland	1783	9,350
7. Kelut, Indonesia	1919	5,110
8. Galunggung, Indonesia	1882	4,011
9. Vesuvius, Italy	1631	3500
10. Vesuvius, Italy	79	3,360

Source: Husain, M., 2009, **Funadamental of Physical Geography**, Jaipur, Rawat Publications.

Table 6.34: *Deadliest Earthquakes*

Location	*Year*	*Deaths*
1. Shanxi, China	1556	830,000
2. Tangshan, China	1976	255,000
3. Halab, (Aleppo) Syria	1938	230,000
4. Near Xining, China	1927	200,000
5. Damghan, Iran	1856	200,000
6. Gansu, China	1920	200,000
7. Ardabil, Iran	1893	150,000

8.	Kwanto, Japan	1923	143,000
9.	Ashkabad (Turkmenistan)	1948	110,000
10.	Messina, Italy	1908	100,000
11.	Tohoku (Japan)	11th March , 2011	>25,000

Source: Husain, M., 2009, **Fundamentals of Physical Geography,** Jaipur, Rawat Publications.

Tables 6.35: Facts About the Countries of Africa

	Country/dependency	*Capital(s)*	*Area in km²*	*Population*	*Density of population*
1.	Algeria	Algiers	2,381,741	32,930,091	13.8
2.	Angola	Luanda	1,246,700	12,127,071	9.7
3.	Benin	Porto-Nova	112,622	7,862,944	70.0
4.	Botswana	Gaborone	582,356	1,639,833	3.0
5.	Burkina Faso	Ouagadougou	267,950	13,902,972	52.0
6.	Burundi	Bujumbura	27,816	8,090,068	290.8
7.	Cameroon	Yaounde	475,442	17,340,702	36.5
8.	Cape Verde	Praia	4,033	420,979	104.4
9.	Central African Republic	Bangui	622,436	4,303,356	7.0
10.	Chad	N'Djamena	1,284,000	9,944,201	7.7
11.	Comoros	Moroni	1,862	690,948	371.1
12.	Congo, D.R.	Kinshasa	2,344,858	62,660,551	26.7
13.	Congo Republic	Brazzaville	342,000	3,702,314	10.8
14.	Cote D'Ivoire	Yamoussoukro (Abidjan)	320,803	17,654,843	55.0
15.	Djibouti	Djibouti	23,200	486,530	21.0
16.	Egypt	Cairo	997,739	78,887,007	79.1
17.	Equatorial Guinea	Malabo	28,051	540,109	19.3
18.	Eritrea	Asmara	121,100	4,786,994	39.5
19.	Ethiopia	Addis Ababa	1,127,127	74,777,981	66.3
20.	Gabon	Libreville	267,667	1,424,906	5.3
21.	Gambia	Banjul	10,689	1,641,564	154.0
22.	Ghana	Accra	238,533	22,409,572	93.9
23.	Guinea	Conakry	245,836	9,690,222	39.4
24.	Guinea-Bissau	Bissau	36,125	1,442,029	39.9
25.	Kenya	Nairobi	582,646	34,707,817	59.6
26.	Lesotho	Maseru	30,355	2,022,331	66.6
27.	Liberia	Monrovia	99,067	3,042,004	30.7
28.	Libya	Tripoli	1,759,540	5,900,754	3.4
29.	Madagascar	Antananarivo	587,041	18,595,469	31.7
30.	Malawi	Lilongwe	118,484	13,013,926	109.8

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31.	Mali	Bamako	1,248,574	11,716,829	9.4
32.	Mauritania	Nouakchott	1,030,700	3,177,388	3.1
33.	Mauritius	Port Louis	2,040	1,240,827	680.2
34.	Morocco	Rabat	456,550	33,241,259	72.8
35.	Mozambique	Maputo	812,379	19,686,505	24.2
36.	Namibia	Windhoek	825,118	2,044,147	6.4
37.	Niger	Niamey	1,189,546	12,525,094	10.5
38.	Nigeria	Abuja	923,768	131,859,731	142.7
39.	Rwanda	Kigali	26,338	8,648,248	328.4
40.	Sao Tome & Principe	Sao Tome	1001	193,413	193.2
41.	Senegal	Dakar	196,722	11,987,121	61.0
42.	Seychelles	Victoria	455	81,541	179.2
43.	Sierra Leone	Freetown	71,740	6,005,250	83.7
44.	Somalia	Mogadishu	673,000	8,863,338	13.9
45.	South Africa	Tshawane (Pretoria)	1,219,090	44,187,637	36.2
46.	Sudan	Khartoum, Omdurman	2,503,890	41,236,378	16.5
47.	Swaziland	Mbabane, Lobamba	17,364	1,136,334	65.4
48.	Tanzania	Dodoma, Dar-es-Salaam	942,799	37,445,392	39.7
49.	Togo	Lome	56,785	5,548,702	98.0
50.	Tunisia	Tunis	163,610	10,175,014	62.2
51.	Uganda	Kampala	241,038	28,195,754	117.0
52.	Western Sahara	El-Aauin (Laayoune)	266,000	273,008	1.0
53.	Zambia	Lusaka	752,612	11,502,010	15.3
54.	Zimbabwe	Harare	390,757	12,236,805	31.3

Source: Extracted from **The Nystrom Desk Atlas,** Indianapolis Herff Jones Education Division.

***Table 6.36:** Asia – Country Table*

	Country	*Capital*	*Area in sq km*	*Population population*	*Density of*
1.	Afghanistan	Kabul	645,807	31,056,997	48.1
2.	Bahrain	Manama	718	698,585	973.0
3.	Bangladesh	Dhaka	147,570	147,365,352	999.0
4.	Bhutan	Thimphu	38,394	2,279,723	59.4
5.	Brunei	Bandar Seri Begawan	5,765	379,444	68.5
6.	Cambodia	Phnom Penh	181,035	13,881,427	76.7

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7.	China	Beijing	9,572,900	1,313,973,715	137.3
8.	Cyprus	Nicosia	5,896	784,301	133.0
9.	East Timor	Dili	14,604	1,062,777	73.0
10.	India	New Delhi	3,166,414	16,854,000	382.0
11.	Indonesia	Jakarta	1,890,754	245,452,739	130.0
12.	Iran	Tehran	1,629,807	68,688,433	42.1
13.	Iraq	Baghdad	434,128	26,783,383	61.7
14.	Israel	Jerusalem	21,671	6,352,117	293.1
15.	Japan	Tokyo	377,873	127,463,611	337.3
16.	Jordan	Amman	89,342	5,906,760	66.1
17.	Kazakhstan	Astana	2,724,900	15,233,244	5.6
18.	Kuwait	Kuwait	17,818	2,418,393	136.0
19.	Kyrgyzstan	Bishkek	199,945	5,213,898	26.1
20.	Laos	Vientiane	236,800	6,368,481	26.9
21.	Lebanon	Beirut	10,400	3,874,050	372.0
22.	Malaysia	Kuala Lumpur	329,847	24,385,858	74.0
23.	Maldives	Male	298	359,008	1,205.0
24.	Mongolia	Ulanbator	1,564,160	2,832,244	1.8
25.	Myanmar	Nay Pyi Taw (Yangoon)	676,577	47,382,633	70.0
26.	Nepal	Kathmandu	147,181	28,287,147	192.2
27.	North Korea	Pyongyang	122,762	23,113,019	188.3
28.	Oman	Muscat	309,500	3,102,229	10.0
29.	Pakistan	Islamabad	796,096	165,803,560	208.3
30.	Philippines	Manila	316,294	89,468,677	282.9
31.	Qatar	Doha	11,427	885,359	77.5
32.	Saudi Arabia	Riyadh	2,149,690	27,019,731	12.6
33.	Singapore	Singapore	697	4,492,150	6445.0
35.	South Korea	Seoul	99,900	48,846,823	489.0
35.	Sri Lanka	Colombo	65,610	20,222,240	308.0
36.	Syria	Damascus	185,180	18,881,361	102.0
37.	Taiwan	Taipei	36,179	23,036,087	636.7
38.	Tajikistan	Dushanbe	143,100	7,320,815	51.2
39.	Thailand	Bangkok	513,120	64,631,595	126.0
40.	Turkey	Ankara	774,815	70,413,958	91.0
41.	Turkmenistan	Ashgabat (Ashkabad)	488,100	5,042,920	10.3
42.	United Arab Emirates	Abu Dhabi	83,600	2,602,713	31.1
43.	Uzbekistan	Tashkent	447,400	27,307,134	158.1
44.	Vietnam	Hanoi	332,501	84,402,966	254.0
45.	Yemen	Sanaa	555,000	21,456,188	39.0

Source: The **Nystrom Desk Atlas,** Indianapolis, Herff Jones Education Division

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Table 6.37: *Australia and Oceania – Country Table*

	Country	Capital	Area in sq km	Population	Density of population
1.	Australia	Canberra	7,692,208	20,264,082	2.6
2.	Fiji	Suva	18,272	905,949	49.6
3.	Kiribati	Bairiki	811	105,432	130.0
4.	Marshal Islands	Rita	181	60,422	334.0
5.	Micronesia	Palikir	701	108,004	154.1
6.	Nauru	Yaren District	21	13,287	627.0
7.	New Caledonia	Noumea	18,575	219,246	30.6
8.	New Zealand	Wellington	270,534	4,076,140	15.0
9.	Palau	Melekeok	488	20,580	42.2
10.	Papua New Guinea	Port Moresby	462,840	5,670,544	12.3
11.	Samoa	Apia	2,831	176,908	62.5
12.	Soloman Islands	Honiara	28,370	552,438	20.0
13.	Tonga	Nuku'alofa	750	114,689	153.0
14.	Tuvalu	Vaiaku	26	11,810	461.3
16.	Vanutu	Port Vila	12,190	208,869	17.1

Source: **The Nystrom Desk Atlas,** Indianapolis, Herff Jones Education Division.

Table 6.38: *Europe: Country Table*

	Country	Capital	Area in sq km	Population	Density of population
1.	Albania	Tirana	28,703	3,581,655	125.0
2.	Andorra	Andorra la Vella	464	71,201	154.0
3.	Armenia	Yerevan	29,743	2,976,372	100.1
4.	Austria	Vienna	83,871	8,192,880	98.0
5.	Azerbaijan	Baku	86,600	7,961,619	92.0
6.	Belarus	Minsk	207,600	10,293,011	49.6
7.	Belgium	Brussels	30,528	10,379,067	340.0
8.	Bosnia & Herzegovina	Sarajevo	51,209	4,498,976	88.0
9.	Bulgaria	Sofia	111,002	7,385,367	66.5
10.	Croatia	Zagreb	56,594	4,494,749	79.4
11.	Czech Republic	Prague	78,866	10,235,455	130.0
12.	Denmark	Copenhagen	43,098	5,450,661	126.6
13.	Estonia	Tallin	43,431	1,324,333	30.5
14.	Finland	Helsinki	338,145	5,231,372	15.5
15.	France	Paris	543,965	60,876,136	112.0
16.	Georgia	Tbilisi	70,152,	4,661,473	66.4

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17.	Germany	Berlin	357,023	82,422,299	231.0
18.	Greece	Athens	131,957	10,688,058	81.0
19.	Hungary	Budapest	93,030	9,981,334	107.3
20.	Iceland	Reykjavik	102,928	299,388	2.9
21.	Ireland	Dublin	70,273	4,062,235	57.8
22.	Italy	Rome	301,277	58,133,509	193.0
23.	Latvia	Riga	64,589	2,274,735	35.2
24.	Liechtenstein	Vaduz	160	33,987	212.4
25.	Lithuania	Vilnius	65,300	3,585,906	54.9
26.	Luxembourg	Luxemburg	2,586	474,413	183.5
27.	Macedonia	Skopje	25,713	2,050,554	79.7
28.	Malta	Valletta	315	400,214	1,270.5
29.	Moldova	Chisinau	33,845	4,466,706	132.0
30.	Monaco	Monaco	1,95	32,543	16,688.7
31.	Montenegro	Podgorica	13,812	630,548	45.7
32.	Netherlands	Amsterdam /The Hague	41,528	16,491,461	397.1
33.	Norway	Oslo	323,758	4,610,820	14.2
34.	Poland	Warsaw	312,685	38,536,869	123.2
35.	Portugal	Lisbon	92,152	10,605,870	115.1
36.	Romania	Bucharest	238,391	22,303,552	93.6
37.	Russia	Moscow	17,075,400	142,893,540	8.4
38.	San Marino	San Marino	61,00	29,251	479.5
39.	Serbia	Belgrade	88,361	9,396,411	106.3
40.	Slovakia	Bratislava	49,035	5,439,448	110.9
41.	Slovenia	Ljubljana	20,273	2,010,347	99.2
42.	Spain	Madrid	505,988	40,397,842	79.8
43.	Sweden	Stockholm	450,295	9,016,596	20.0
44.	Switzerland	Bern, Lausanne	41,284	7,523,934	182.2
45.	Ukraine	Kiev	603,628	46,710,816	77.4
46.	United Kingdom	London	242,910	60,609,153	249.5
47.	Vatican City	Vatican City	0,44	932	2118.2

Source: **The Nystrom Desk Atlas,** Indianapolis, Herff Jones Education Division.

***Table 6.39:** North America–Country table*

	Country	*Capital*	*Area in sq km*	*Population population*	*Density of*
1.	Antigua and Barbuda	Saint John's	442	69,108	156.4
2.	Aruba (Neth.)	Oranjestad	193	71,891	372.5

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3.	Bahamas	Nassau	13,939	303,770	21.8
4.	Barbados	Bridgetown	22,965	287,730	12.5
5.	Canada	Ottawa	9,984,670	33,098,932	3.3
6.	Costa Rica	San Jose	51,100	4,075,261	79.8
7.	Cuba	Havana	110,861	11,382,820	103.0
8.	Dominica	Roseau	739	68,910	93.2
9.	Dominican Republic	Santo Domingo	48,671	9,183,984	488.7
10.	El Salvador	San Salvador	21,042	6,822,378	324.2
11.	Grenada	Saint George's	344	89,703	260.8
12.	Guadeloupe (Fr.)	Basse-Terre	1705	452,776	265.6
13.	Guatemala	Guatemala City	109,117	12,293,545	112.7
14.	Haiti	Port-au-Prince	27,700	8,305,504	299.9
15.	Honduras	Tegucigalpa	112,492	7,326,496	65.1
16.	Jamaica	Kingston	10,991	2,758,124	250.9
17.	Martinique (Fr.)	Forte-de-France	1128	436,131	386.6
18.	Mexico	Mexico City	1,964,375	107,449,525	54.7
19.	Netherlands Antilles (Neth.)	Willemstad	800	5,570,129	42.7
20.	Nicaragua	Managua	130,373	5,570,129	42.7
21.	Panama	Panama City	75,040	3,191,319	42.3
22.	Puerto Rico	San Juan	9,104	3,927,188	431.4
23.	Saint Kitts & Nevis	Basseterre	269	39,129	145.5
24.	Saint Lucia	Castries	617	168,458	273.0
25.	Saint Vincent & Grenadines	Kingston	389	117,848	303.0
26.	Trinidad & Tobago	Port of Spain	5,127	1,065,842	207.9
27.	United States	Washington, D.C.	9,522,058	298,444,215	31.3

Source: **The Nystrom Desk Atlas,** Indianapolis, Herff Jones Education Division.

***Table 6.40:** South America – Country Table*

	Country	*Capital*	*Area in sq km*	*Population population*	*Density of*
1.	Argentina	Buenos Aires	2,780,092	39,921,833	14.4
2.	Bolivia	La Paz, Sucre	1,098,581	8,989,046	21.2
3.	Brazil	Brasilia	8,514,877	188,078,227	22.1
4.	Chile	Santiago	756,096	16,134,219	21.3
5.	Colombia	Bogota	1,141,568	43,593,035	38.2
6.	Ecuador	Quito	272,045	13,547,510	50.0
7.	French Guiana	Cayenne	83,534	199,509	2.4

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8.	Guyana	Georgetown	215,083	767,245	3.6
9.	Paraguay	Asuncion	406,752	6,506,464	16.0
10.	Peru	Lima	1,285,216	28,302,603	22.0
11.	Surinam	Paramaribbo	163,820	439,117	2.7
12.	Uruguay	Montevideo	176,215	3,431,932	19.5
13.	Venezuela	Caracas	916,445	25,730,435	28.1

Source: **The Nystrom Desk Atlas**, Indianapolis, Herff, Jones Education Division.

***Table 6.41:** Important Cities Situated along the River-side*

	City	*River*	*Country*
1.	Alexandria	Nile	Egypt
2.	Amsterdam	Amsel	The Netherlands
3.	Antwerp	Scheldt	Belgium
4.	Ankara	Kizil	Turkey
5.	Baghdad	Tigris	Iraq
6.	Bangkok	Chao Phraya	Thailand
7.	Belgrade	Danube	Yugoslavia
8.	Berlin	Spree	Germany
9.	Bonn	Rhine	Germany
10.	Bristol	Avon	England
11.	Cairo	Nile	Egypt
12.	Canton	Canton	China
13.	Cologne	Rhine	Germany
14.	Dhaka	Padma	Bangladesh
15.	Glasgow	Clyde	Scotland (U.K.)
16.	Hull	Humber	England
17.	Hamburg	Elbe	Germany
18.	Karachi	Indus	Pakistan
19.	Khartoum	Nile	Sudan
20.	Lahore	Ravi	Pakistan
21.	Lisbon	Tagus	Portugal
22.	Liverpool	Mersey	England
23.	London	Thames	England
24.	Montreal	St. Lawrance	Canada
25.	Moscow	Moskava	Russia
26.	New Orleanse	Mississippi	USA
27.	New York	Hudson	USA
28.	Paris	Seine	France
29.	Philadelphia	Delaware	USA
30.	Rangoon	Irrawaddy	Myanmar

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31. Rome	Tiber	Italy
32. Shanghai	Yang-tse-kiang	China
33. Tokyo	Sumida	Japan
34. Vienna	Danube	Austria
35. Volgograd	Volga	Russia
36. Warsaw	Vistual	Poland
37. Washington, D.C.	Potamac	USA
38. Wuhan	Yangtze Kiang	China

Facts about the Countries

Afghanistan

Population 32,254,372
Land area: 652,090 km^2
Capital: Kabul
Population density: 49 persons per sq km
Life expectancy at birth: 48 years
Adult literacy rate: 25%
Urban population: 25%
Currency: Afghani
Language: Pasthu, Dari

Albania

Population: 3,163,250
Land area: 28,750 km^2
Capital: Tirane (Tirane)
Population desnity: 110 persons per sq km
Life expectancy at birth: 74 years
Adult literacy rate: 99%
GNI per capita: $2120
Urban population : 46%
Currency: New lik
Language: Albania, Tosk

Algeria/Al Jazair

Population: 33,861,333
Land area: 2,381,740 km^2
Capital: Algiers (Alger)
Population density: 14 persons per sq km
Life expectancy at birth: 72 years
Adult literacy rate: 70%
GNI per capita: $2270
Urban population: 61%
Currency: Dinar
Language: Arabic, Tamazight

Andorra

Population: 67,450
Land area: 453 sq km
Capital: Andorra la Valla
Population density:149 persons per sq km
Adult literacy rate: 100%
Urban population: 100%
Language: Catalan

Angola

Population: 16,867,260
Land area: 1,246,700 sq km
Capital: Luanda
Population density: 14 persons per sq km
Life expectancy at birth: 42 years
Adult literacy rate: 67%
GNI per capita: $930
Urban population: 39%
Currency: New Kawanza
Language: Portuguese

Anguilla

Population: 12,568
Land area: 96 sq km
Capital: The Valley
Density of population: 131 persons per sq km
Urban population: 100%
Currency: EC dollar
Language: English

Antigua and Barbuda

Population: 83,514
Land area: 440 sq km
Capital: St. John's
GNI per capita: $9480

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Density of population: 190 persons per sq km
Currency: EC dollar
Language: English

Argentina

Population: 39,531,118
Land area: 2,780,400 sq km
Capital: Buenos Aires
Density of population: 14 persons per sq km
Life expectancy at birth: 75 years
Adult literacy rate: 97%
GNI per capita: $3580
Urban population: 91%
Currency: Peso
Language: Spanish

Armenia

Population: 2,999,187
Land area: 29,800 sq km
Capital: Yervan
Population density: 101 persons per sq km
Life expectancy at birth: 72 years
Adult literacy rate: 99%
GNI per capita: $1060
Urban population: 64%
Currency: Dram
Language: Armenia

Aruba

Population: 101,357
Land area: 190 sq km
Capital: Oranjestad
Density of population: 533 persons per sq km
Currency: Aruba florin
Language: Dutch

Australia

Population: 20,575,932
Land area: 7,741,220
Capital: Canberra
Density of population: 3 persons per sq km
Life expectancy at birth: 81 years
GNI per capita: $27,070
Urban population: 93%
Currency: Australian dollar
Language: English

Austria

Population: 8,217,583
Land area: 83,860 sq km
Capital: Vienna (Wien)
Density of population: 98 persons per sq km
Life expectancy at birth : 80 years
Literacy rate: 99%
GNI per capita: $32,280
Urban population: 66%
Currency: Euro
Language: German

Azerbaijan

Population: 8,535,733
Land area: 86,600 sq km
Capital: Baku
Density of population: 99 persons per sq km
Life expectancy at birth: 67 years
Adult literacy rate: 99%
GNI per capita: $940
Urban population: 50%
Currency: Manat
Language: Azeri

Bahamas

Population: 331,643
Land area: 13,880 sq km
Capital: Nassau
Density of population: 24 persons per sq km
Life expectancy at birth: 72 years
GNI per capita: $15,100
Urban population: 90%
Currency: Bahamian dollar
Language: English

Bahrain

Population: 751,320
Land area: 710 sq km
Capital: Manama
Density of population: 1058 persons per sq km
Life expectancy at birth: 75 years
Adult literacy rate: 88%
GNI per capita: $14,370
Urban population: 90%
Currency: Dinar
Language: Arabic

Bangladesh

Population: 152,592,662
Land area: 144,000 sq km
Capital: Dhaka (Dacca)

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Density of population: 1021 persons per sq km
Life expectancy at birth: 65 years
Adult literacy rate: 41%
GNI per capita: $440
Urban population: 26%
Population living under one dollar per day: 36%
Currency: Taka
Language: Bangla/Bengali

Barbados

Population: 270,903
Land area: 430 sq km
Capital: Bridgetown
Density of population: 630 persons per sq km
Life expectancy at birth: 76 years
Adult literacy rate: 100%
GNI per capita: $8670
Urban population: 54%
Currency: Barbadian dollar
Language: English

Belarus

Population: 9,645,192
Land area: 207,600 sq km
Capital: Minsk
Density of population: 46 persons per sq km
Life expectancy at birth: 69 years
Adult literacy rate: 100%
GNI per capita: $2140
Urban population: 72%
Currency: Rouble
Language: Belarusian

Belgium/Belgie/Belgique

Population: 10,453,494
Land area: 33,100 sq km
Capital: Brussels (Brussel/Bruxelles)
Density of population: 316 persons per sq km
Life expectancy at birth: 80 years
Literacy rate: 100%
GNI Per Capita: $31,280
Urban population: 97%
Currency: Euro
Language: Dutch/French

Belize/Belize

Population: 280,439
Land area: 22,960 sq km
Capital: Belmopan
Density of population: 12 persons per sq km
Life expectancy at birth: 72 years
Adult literacy rate: 77%
GNI Per Capita: $3840
Urban population: 49%
Currency: Belze dollar
Language: English

Benin

Population: 8,971,037
Land area: 112,620 sq km
Capital: Porto Nova
Density of population: 80 persons per sq km
Life expectancy at birth: 56 years
Adult literacy rate: 34%
GNI Per Capita: $450
Urban population: 48%
Population living under one dollar per day: 30%
Currency: CFA Franc
Language: French

Bermuda

Population: 64,559
Land area: 50 sq km
Capital: Hamilton
Density of population: 1291 persons per sq km
GNI Per Capita: $35,590
Currency: Bermuda dollar
Language: English

Bhutan

Population: 2,260,152
Land area: 47,000 sq km
Capital: Thimpu
Density of population: 48 persons per sq km
Life expectancy at birth: 65 years
Literacy rate: 65%
GNI per Capita: $760
Urban population: 10%
Currency: Ngultrum
Language: Dzongkha

Bolivia

Population: 9,524,569
Land area: 1,098,580 sq km
Capital: La Paz
Density of population: 9 persons per sq km

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Life expectancy at birth: 66 years
Adult literacy rate: 87%
GNI Per Capita: $960
Urban population: 65%
Population living under one dollar per day: 23%
Currency: Boliviano
Language: Spanish, Quechua and Amyara

Bosnia-Herzegovina

Population: 3,919,695
Land area: 51,130 sq km
Capital: Sarajevo
Density of population: 77 persons per sq km
Life expectancy at birth 75 years
Adult literacy rate: 95%
GNI Per Capita: $2040
Urban population: 46%
Currency: Konvertibilina Marka/(KM)

Botswana

Population: 1,753,135
Land area: 581,730 sq km
Capital: Gaborone
Density of population: 3 persons per sq km
Life expectancy at birth: 34 years
Adult literacy rate: 79%
GNI Per Capita: $4360
Urban population: 53%
Currency: Pula
Language: Setswana

Brazil

Population: 191,341,355
Land area: 8,547,400 sq km
Capital: Brasilia
Density of population: 22 persons per sq km
Life expectancy at birth: 72 years
Adult literacy rate: 88%
GNI Per Capita: $3000
Urban population: 85%
Currency: Real
Language: Portuguese

Brunei

Population: 390,042
Land area: 5,770 sq km
Capital: Bandar Seri Begawan
Density of population: 68 persons per sq km
Life expectancy at birth: 73 years
GNI Per Capita : $5540
Adult literacy rate: 93%
GNI Per Capita: $5540
Urban population: 79%
Currency: Brunei dollar
Language: Brhasa Malaya

Bulgaria

Population: 7,615,710
Land area: 110,910 sq km
Capital: Sofia (Sofija)
Density of population: 69 persons per sq km
Adult literacy rate: 98%
Urban population: 71%
GNI Per Capita: $2750
Currency: Leva
Language: Bulgarian

Burkina Faso

Population:14,042,328
Land area: 274,000 sq km
Capital: Ouagadougou
Density of population: 51 persons per sq km
Life expectancy at birth: 49 years
Adult literacy rate: 13%
GNI Per Capita: $350
Urban population: 19%
Population living under one dollar per day: 27.5%
Currency: CFA Arabic
Language: French

Burundi

Population: 8,140,849
Land area: 27,830 sq km
Capital: Bujumbura
Density of population: 293 persons per sq km
Life expectancy at birth: 46 years
Adult literacy rate: 59%
GNI Per Capita: $90
Urban population: 11%
Population living under one dollar per day: 57%
Currency: Burundi franc
Language: Rundi, Kirundi and French

Cambodia

Population: 14,638,056
Land area: 181,040 sq km
Capital: Phnom Penh
Density of population: 81 persons per sq km
Life expectancy at birth: 58 years
Adult literacy rate: 74%

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GNI Per Capita: $350
Urban population: 21%
Population living under one dollar per day: 34%
Currency: Riel
Language: Khmer

Cameroon

Population: 16,874,394
Land area: 475,440 sq km
Capital: Yaounde
Density of population: 35 persons per sq km
Life expectancy at birth: 46 years
Adult literacy rate: 68%
GNI Per Capita: $810
Urban population: 54%
Population living under one dollar per day: 17%
Currency: CFA frank
Language: French and English

Canada

Population: 32,852,154
Land area: 9,970,610 sq km
Capital: Ottawa
Density of population: 3 persons per sq km
Life expectancy at birth: 81 years
GNI Per Capita: $28,310
Urban population: 82%
Currency: Canadian dollar
Language: English and French

Cape Verde

Population: 530,438
Land area: 4,030 sq km
Capital: Praia
Density of population: 132 persons per sq km.
Life expectancy at birth: 72 years
Adult literacy rate: 76%
GNI Per Capita: $1720
Urban population: 59%
Currency: Escudo
Language: Portuguese

Cayman Islands

Population: 46,628
Land area: 260 sq km
Capital: George Town
Density of population: 179 persons per sq km
Currency: Cayman dollar
Language: English

Central African Republic

Population: 4,150,553
Land area: 622,980 sq km
Capital: Bangui
Density of population: 7 persons per sq km
Life expectancy at birth: 40 years
Adult literacy rate 49%
GNI Per Capita: $310
Urban population: 45%
Currency: CFA franc
Language: French

Chad

Population: 10,302,807
Land area: 1,284,000 sq km
Capital: N'Djamena
Density of population: 8 persons per sq km
Life expectancy at birth: 44 years
Adult literacy rate: 26%
GNI Per Capita: $250
Urban population: 27%
Currency: CFA franc
Language: Arabic and French

Chile

Population:16,634,762
Land area: 756,630 sq km
Capital: Santiago
Density of population: 8 persons per sq km
Life expectancy at birth: 79 years
Adult literacy rate: 96%
GNI Per Capita: $5220
Urban population: 88%
Currency: Peso
Language: Spanish

China

Population:1,331,355,908
Land area: 9,598,050 sq km
Capital: Beijing
Density of population: 139 persons per sq km
Life expectancy at birth: 73 years
Adult literacy rate: 91%
GNI Per Capita: $1500
Urban population: 42%
Population under one dollar per day: 16.6%

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Currency: Renminbi (Yuan)
Language: Chinese

Colombia

Population: 45,600,244
Land area: 1,138,910
Capital: Bogota
Density of population: 41 persons per sq km
Life expectancy at birth: 73 years
Adult literacy rate: 94%
GNI Per Capita: $2020
Urban population: 78%
Currency: Peso
Language: Spanish

Comoros

Population: 840,855
Land area: 2,230 sq km
Capital: Moroni
Density of population: 377 persons per sq km
Life expectancy at birth: 65 years
Adult literacy rate: 56%
GNI Per Capita: $560
Urban population: 38%
Currency: Comorosw frank
Language: Arabic and French

Congo Democratic Republic

Population; 61,173,695
Land area: 2,344,860 sq km
Capital: Kinshasha
Density of population: 22 persons per sq km
Life expectancy at birth: 45 years
Adult literacy rate: 65%
GNI Per Capita: $110
Urban population: 34%
Currency: New Zaire
Language: French

Congo Republic

Population: 4,237,655
Land area: 342,000 sq km
Capital: Brazzaville
Density of population:12 persons per sq km
Life expectancy at birth: 54 years
Adult literacy rate: 83%
GNI Per Capita: $760
Urban population: 55%
Currency: CFA franc
Language: Fren

Costa Rica

Population: 4,467,626
Land area: 51,100 sq km
Capital: San Jose
Density of population: 87 persons per sq km
Life expectancy at birth: 79 years
Adult literacy rate: 96%
GNI Per Capita: $4470
Urban population: 63%
Currency: Colon
Language: Spanish

Cote d'Ivoire (Ivory Coast)

Population: 18,769,704
Land area: 322,460 sq km
Capital: Yamoussoukro/Abidjan
Density of population: 58 persons per sq km
Life expectancy at birth: 46 years
Adult literacy rate: 48%
Urban population: 47%
GNI Per Capita: $760
Population living under one dollar per day: 14.8%
Currency: CFA franc
Language: French

Croatia

Population: 4,555,216
Land area: 56,540 sq km
Capital: Zagreb
Density of population: 81 persons per sq km
Life expectancy at birth: 76 years
Adult literacy rate: 98%
GNI Per Capita: $6820
Urban population: 61%
Language: Croatian

Cuba

Population: 11,317,087
Land area: 110,860 sq km
Capital: Havana (La Habana)
Density of population: 102 persons per sq km
Life expectancy at birth: 79 years
Adult literacy rate: 100%

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Urban population: 76%
Currency: Peso
Language: Spanish

Cyprus

Population: 853,765
Land area: 9,250 sq km
Capital: Levkosia (Nicosia)
Density of population: 92 persons per sq km
Life expectancy at birth: 79 years
Adult literacy rate: 97%
GNI Per Capita: $16,510
Urban population: 70%
Currency: Pound
Language: Greek and Turkish

Czech Republic

Population: 10,197,995
Land area: 78,870 sq km
Capital: Prague
Density of population: 129 persons per sq km
Life expectancy at birth: 76 years
GNI Per Capita: $9130
Urban population: 75%
Currency: Koruny
Language: Czech

Denmark

Population: 5,461,197
Land area: 43,090 sq km
Capital: Copenhagen
Density of population: 127 persons per sq km
Life expectancy at birth: 78 years
GNI Per Capita: $40,750
Urban population: 86%
Currency: Kroner
Language: Danish

Djibouti

Population: 820,183
Land area: 23,200 sq km
Capital: Djibouti
Density of population: 35 persons per sq km
Life expectancy at birth: 54 years
GNI Per Capita: $950
Urban population: 85%
Currency: Franc
Language: French/Arabic

Dominica

Population: 80,389
Land area: 750 sq km
Capital: Roseau
Density of population: 107 persons per sq km
GNI Per Capita: $3670
Urban population: 100%
Currency: EC dollar
Language: English

Dominican Republic

Population: 9,147,614
Land area: 48,730 sq km
Capital: Santo Domingo
Density of population: 188 persons per sq km
Life expectancy at birth: 69 years
Adult literacy rate: 88%
GNI Per Capita: $2100
Urban population: 61%
Currency: Peso
Language: Spanish

Ecuador

Population: 13,610,733
Land area: 283,560 sq km
Capital: Quito
Density of population: 48 persons per sq km
Life expectancy at birth: 75 years
Adult literacy rate: 91%
GNI Per Capita: $2210
Urban population: 64%
Population living under one dollar per day: 15.8%
Currency: US dollar
Language: Spanish

Egypt

Population: 76,853,305
Land area: 1,001,450 sq km
Capital: Cairo (Al-Qahirah)
Density of population: 77 persons per sq km
Life expectancy at birth: 71 years
Adult literacy rate: 56%
GNI Per Capita: $1250
Urban population: 43%
Currency: Pound
Language: Arabic

El Salvador

Population: 7,115,616

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Land area: 21,040 sq km
Capital: San Salvador
Density of population: 338 persons per sq km
Life expectancy at birth: 72 years
Adult literacy rate: 56%
GNI Per Capita: $2320
Urban population: 61%
Currency: Dollar, Colon
Language: Spanish

Equatorial Guinea

Population: 526,659
Land area: 28,050 sq km
Capital: Malabo
Density of population: 19 persons per sq km
Life expectancy at birth: 42 years
Adult literacy rate: 84%
GNI Per Capita: $710
Urban population: 52%
Currency: CFA franc
Language: Spanish and French

Eritrea

Population: 4,708,085
Land area: 117,600 sq km
Capital: Asmara
Density of population: 40 persons per sq km
Life expectancy at birth: 56 years
GNI Per Capita: $190
Urban population: 22%
Currency: Nafka
Language: Tigrinya

Estonia

Population: 1,320,530
Land area: 45,100 sq km
Capital: Talinin
Density of population: 70 persons per sq km
Life expectancy at birth: 73 years
Adult literacy rate: 100%
GNI Per Capita: $7080
Urban population: 70%
Currency: Kroon
Language: Estonia

Ethiopia

Population: 81,176,369
Land area: 1,104,300 sq km
Capital: Addis Ababa
Density of population: 74 persons per sq km
Life expectancy at birth: 73 years
Adult literacy rate: 42%
GNI Per Capita: $110
Urban population: 17%
Population living under one dollar per day: 23%
Currency: Birr
Language: Amharic

Fiji

Population: 860,741
Land area: 18,270 sq km
Capital: Suva
Density of population: 47 persons per sq km
Life expectancy at birth: 69 years
Adult literacy rate: 93%
GNI Per Capita: $2720
Urban population: 55%
Currency: Fiji dollar
Language: English

Finland

Population: 5,273,845
Land area: 338,150 sq km
Capital: Helsinki
Density of population: 16 persons per sq km
Life expectancy at birth: 79 years
GNI Per Capita: $32,880
Urban population: 61%
Currency: Euro
Language: Finnish, Swedish

France

Population: 60,940,373
Land area: 551,500 sq km
Capital: Paris
Density of population: 110 persons per sq km
Life expectancy at birth: 80 years
GNI Per Capita: $30,370
Urban population: 77%
Currency: Euro
Language: French

French Guyana

Population: 195,916
Land area: 90,000 sq km
Capital: Cayenne

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Density of population: 2 persons per sq km
Life expectancy at birth: 76 years
Urban population: 76%
Currency: Euro
Language: French

Gabon

Population: 1,428,934
Land area: 267,670 sq km
Capital: Libreville
Density of population: 5 persons per sq km
Life expectancy at birth: 53 years
GNI Per Capita : $4080
Urban population: 86%
Currency: CFA franc
Language: French

Gambia

Population: 1,593,959
Land area: 11,300 sq km
Capital: Banjul
Density of population: 141 persons per sq km
Life expectancy at birth: 58 years
GNI Per Capita: $280
Urban population: 26%
Population living under one dollar per day: 59%
Currency: Dalasi
Language: English

Georgia

Population: 4,395,798
Land area: 69,700 sq km
Currency: Kupon
Capital: Tbilisi
Density of population: 63 persons per sq km
Life expectancy at birth: 71 years
GNI Per Capita: $1060
Urban population: 51%
Language: Georgian

Germany

Population: 82,728,564
Land area: 357,030 sq km
Capital: Berlin
Density of population: 232 persons per sq km
Life expectancy at birth: 80 years
GNI Per Capita: $30,690
Urban population: 89%
Currency: Euro
Language: German

Ghana

Population: 22,994,743
Land area: 238,540 sq km
Capital: Accra
Density of population: 96 persons per sq km
Life expectancy at birth: 58 years
Adult literacy rate: 54%
GNI Per Capita: $2240
Urban population: 47%
Currency: Cedi
Language: English

Greece

Population: 11,159,585
Land area: 131,960 sq km
Capital: Athens
Density of population: 85 persons per sq km
Life expectancy at birth: 79 years
Adult literacy rate: 91%
GNI Per Capita: $16,730
Urban population: 62%
Currency: Euro
Language: Greek

Guadeloupe

Population: 454,579
Land area: 1,705, sq km
Capital: Basse-Terre
Density of population: 267 persons per sq km
Life expectancy at birth: 79 years
Urban population: 100%
Currency: Euro
Language: French

Guam

Population: 174,898
Land area: 550 sq km
Capital: Agana
Density of population: 318 persons per sq km
Life expectancy at birth: 76 years
Urban population: 98%
Currency: US dollar
Language: English

Guatemala

Population: 13,230,423
Land area: 108,890 sq km
Capital: Guatemala
Density of population: 122 persons per sq km

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Life expectancy at birth: 68 years
Adult literacy rate: 61%
GNI Per Capita: $2190
Urban population: 48%
Population living under one dollar per day: 13.5 %
Currency: Quetzal
Language: Spanish

Guinea

Population: 9,808,023
Land area: 245,860 sq km
Capital: Conakry
Density of population: 122 persons per sq km
Life expectancy at birth: 54 years
Adult literacy rate: 55%
GNI Per Capita: $410
Urban population: 48%
Currency: Franc
Language: French

Guinea-Bissau

Population: 1,681,645
Land area: 36,120 sq km
Capital: Bissau
Density of population: 40 persons per sq km
Life expectancy at birth: 54 years
Adult literacy rate: 45%
GNI Per Capita: $160
Urban population : 37%
Currency: Peso
Language: Portuguese

Guyana

Population: 752,312
Land area: 214,970 sq km
Capital: Georgetown
Density of population: 3 persons per sq km
Life expectancy at birth: 65 years
Adult literacy rate: 65%
GNI Per Capita: $1020
Urban population: 39%
Currency: Guyana dollar
Language: English

Haiti

Population: 8,773,138
Land area: 27, 750 sq km
Capital: Port-au-Prince
Currency: Gourde
Density of population: 316 persons per sq km
Life expectancy at birth: 53 years
Adult literacy rate: 52%
GNI Per Capita: $400
Urban population: 40%
Capital: Port-au-Prince
Language: French and Creole

Honduras

Population: 7,520,649
Land area: 112, 090 sq km
Capital: Tegucigalpa
Density of population: 67 persons per sq km
Life expectancy at birth: 69 years
Adult literacy rate: 80%
GNI Per Capita: $1040
Urban population: 47%
Currency: Lempira
Language: Spanish

Hungary

Population: 10,044,557
Land area: 93,030 sq km
Capital: Budapest
Density of population: 108 persons per sq km
Life expectancy at birth: 74 years
Adult literacy rate: 99%
GNI Per Capita: $8370
Urban population: 67%
Currency: Forint
Language: Hungarian

Iceland

Population: 299,686
Land area: 103,000 sq km
Capital: Reykjavik
Density of population: 3 persons per sq km
Life expectancy at birth: 81 years
Adult literacy rate: 99%
GNI Per Capita: $37,920
Urban population: 93%
Currency: Kronur
Language: Icelandic

India

Population: 1210 millions (2011)
Land area: 3,287,260 sq km
Capital: New Delhi

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Density of population: 382 persons per sq km
Life expectancy at birth: 67 years
Adult literacy rate: 65%
GNI Per Capita: $620
Urban population: 29%
Currency: Rupee
Language: Hindi

Indonesia

Population: 228,121,313
Land area: 1,904, 570 sq km
Capital: Jakarta
Density of population: 120 persons per sq km
Life expectancy at birth: 69 years
Adult literacy rate: 88%
GNI Per Capita: $1140
Urban population: 50%
Currency: Rupiah
Language: Bahasa Indonesia

Iran

Population: 71,220,269
Land area: 1,648,200 sq km
Capital: Tehran
Density of population: 43 persons per sq km
Life expectancy at birth: 72 years
Adult literacy rate: 77%
GNI Per Capita: $2320
Urban population: 69%
Currency: Rial
Language: Farsi (Persian)

Iraq

Population: 30,290,517
Land area: 438,320 sq km
Capital: Baghdad
Density of population: 69 persons per sq km
Life expectancy at birth: 61 years
Adult literacy rate: 75%
GNI Per Capita: $2320
Urban population: 67%
Currency: Dinar
Language: Arabic

Ireland

Population: 4,266,555
Land area: 70,270 sq km
Capital: Dublin
Density of population: 61 persons per sq km
Life expectancy at birth: 78 years
Adult literacy rate: 99%
GNI Per Capita: $34,310
Urban population: 61%
Currency: Euro
Language: Irish, English

Israel

Population: 6,967,413
Land area: 20,770 sq km
Capital: Jerusalem/Tel Aviv
Density of population: 331 persons per sq km
Life expectancy at birth: 81 years
Adult literacy rate: 97%
GNI Per Capita: $17360
Urban population: 92%
Currency: New Shekel
Language: Hebrew and Arabic

Italy

Population: 58,173,356
Land area: 301,340 sq km
Capital: Rome (Roma)
Density of population: 193 persons per sq km
Life expectancy at birth: 81 years
GNI Per Capita: $26,280
Urban population: 68%
Currency: Euro
Language: Italian

Jamaica

Population: 2,672,480
Land area: 10,990 sq km
Capital: Kingston
Density of population: 243 persons per sq km
Life expectancy at birth: 71 years
Adult literacy rate: 88%
GNI Per Capita: $3300
Urban population: 52%
Currency: Jamaican dollar
Language: English

Japan

Population: 128,325,473
Land area: 377,800 sq km
Capital: Tokyo
Density of population: 340 persons per sq km

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Life expectancy at birth: 83 years
Adult literacy rate: 100%
GNI Per Capita: 37,050
Urban population: 66%
Currency: Yen
Language: Japanese

Jordan

Population: 5,966,463
Land area: 89,210 sq km
Capital: Amman
Density of population: 67 persons per sq km
Life expectancy at birth: 72 years
Adult literacy rate: 90%
GNI Per Capita: $2190
Urban population: 80%
Currency: Dinar
Language: Arabic

Kanaky–New Caledonia

Population: 245,120
Land area: 18,580 sq km
Capital: Noumee
Density of population: 13 persons per sq km
Life expectancy at birth: 76 years
GNI Per Capita: $14,020
Urban population: 62%
Currency: CFP franc
Language: French

Kazakhstan

Population: 14,802,455
Land area: 2,724,900 sq km
Capital: Astana
Density of population: 5 persons per sq km
Life expectancy at birth: 64 years
Adult literacy rate: 100%
GNI Per Capita: $2250
Urban population: 56%
Currency: Tengue
Language: Kazakh

Kenya

Population: 36,012,332
Land area: 580,370 sq km
Capital: Nairobi
Density of population: 62 persons per sq km
Life expectancy at birth: 50 years
Adult literacy rate: 74%
GNI Per Capita: $480
Urban population: 44%
Population living under one dollar per day: 22.8 %
Currency: Shilling
Language: English and Swahili

Korea, North/Choson

Population: 22,670,156
Land area: 120,540 sq km
Capital: Pyongyang
Density of population: 188 persons per sq km
Life expectancy at birth: 64 years
Urban population: 62%
Currency: Won
Language: Korean

Korea, South/Hanguk

Population: 48,141,554
Land area: 99,260 sq km
Capital: Seoul
Density of population: 485 persons per sq km
Life expectancy at birth: 78 years
GNI Per Capita: $14,000
Urban population: 81%
Currency: Won
Language: Korean

Kuwait

Population: 2,839,305
Land area: 17,820 sq km
Capital: Kuwait City
Density of population: 159 persons per sq km
Life expectancy at birth: 78 years
Adult literacy rate: 83%
GNI Per Capita: $22,470
Urban population: 97%
Currency: Dinar
Language: Arabic

Kyrgyzstan

Population: 5,385,917
Land area: 199,900 sq km
Capital: Bishkek

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Density of population: 27 persons per sq km
Life expectancy at birth: 68 years
Adult literacy rate: 99%
GNI Per Capita: $400
Urban population: 34%
Currency: Som
Language: Kyrgyz

Laos

Population: 6,192,617
Land area: 236,800 sq km
Capital: Vientian
Density of population: 26 persons per sq km
Life expectancy at birth: 56 years
Adult literacy rate: 69%
GNI Per Capita: $390
Urban population: 23%
Population living under one dollar per day: 27%
Currency: New Kip
Language: Lao

Latvia/Latvija

Population: 2,283,563
Land area: 64,600 sq km
Capital: Riga
Density of population: 35 persons per sq km
Life expectancy at birth: 73 years
Adult literacy rate: 100%
GNI Per Capita: $5580
Urban population: 66%
Currency: Lat
Language: Latvian

Lebanon

Population: 3,653,634
Land area: 10,400 sq km
Capital: Beirut (Bayrut)
Density of population: 351 persons per sq km
Life expectancy at birth: 73 years
Adult literacy rate: 90%
GNI Per Capita: $6010
Urban population: 88%
Currency: Pound
Language: Arabic

Lesotho

Population:1,785,311
Land area: 30,350 sq km
Capital: Maseru
Density of population: 59 persons per sq km
Life expectancy at birth: 34 years
Adult literacy rate: 81%
GNI Per Capita: $730
Urban population: 19%
Population living under one dollar per day: 36.4 %
Currency: Loti
Language: Sotho and English

Liberia

Population: 3,452,277
Land area: 111,370 sq km
Capital: Monrovia
Density of population: 31 persons per sq km
Life expectancy at birth: 43 years
Adult literacy rate: 56%
GNI Per Capita: $120
Urban population: 49%
Currency: Liberian dollar
Language: English

Libya/Libiyah

Population: 6,084,909
Land area: 1,759, 540 sq km
Capital: Tripoli (Tarabulus)
Density of population: 31 persons per sq km
Life expectancy at birth: 75 years
Adult literacy rate: 82%
GNI Per Capita: $4400
Urban population: 49%
Currency: Dinar
Language: Arabic

Liechtenstein

Population: 35,135
Land area: 160 sq km
Capital: Vaduz
Density of population: 220 persons per sq km
Urban population: 100%
Currency: Swiss franc
Language: German

Lithuania

Population: 3,402,999
Land area: 65,200 sq km
Capital: Vilnius
Density of population: 52 persons per sq km

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Life expectancy at birth: 73 years
GNI Per Capita: $5740
Adult literacy rate: 100%
Urban population: 67%
Currency: Lit
Language: Lithuanian

Luxembourg

Population: 476,676
Land area: 2600 sq km
Capital: Luxembourg
Density of population: 183 persons per sq km
Life expectancy at birth: 79 years
Adult literacy rate: 56%
GNI Per Capita: $56380
Urban population: 93%
Currency: Euro
Language: Letzebuergish, French, German

Macedonia

Population: 2,039,802
Land area: 25,710 sq km
Capital: Skopje
Density of population: 79 persons per sq km
Life expectancy at birth: 74 years
Adult literacy rate: 96%
GNI Per Capita: $2420
Urban population: 60%
Currency: Denar
Language: Mecedonian/Albania

Madagascar

Population: 19,608,874
Land area: 587,040 sq km
Capital: Antananarivo
Density of population: 33 persons per sq km
Life expectancy at birth: 56 years
Adult literacy rate: 71%
GNI Per Capita: $290
Urban population: 28%
Population living under one dollar per day: 61%
Currency: Franc
Language: Malagasy and French

Malawi

Population: 13,451,817
Land area: 118,480 sq km
Capital: Lilongwe
Density of population: 114 persons per sq km
Life expectancy at birth: 41 years
Adult literacy rate: 64%
GNI Per Capita: $160
Urban population: 18%
Currency: Kwache
Language: Chewa, English

Malaysia

Population: 26,239,500
Land area: 329,750 sq km
Capital: Kuala Lumpur
Density of population: 80 persons per sq km
Life expectancy at birth: 74 years
Adult literacy rate: 89%
GNI Per Capita: $4520
Urban population: 66%
Currency: Ringgit
Language: Bahasa Malaysia

Maldives/Dhivehi Raajje

Population; 345,694
Land area: 300 sq km
Capital: Male
Density of population: 1152 persons per sq km
Life expectancy at birth: 69 years
Adult literacy rate: 96%
GNI Per Capita: $2410
Urban population: 31%
Currency: Rufiyaa
Language: Dhivehi

Mali

Population: 14,324,716
Land area: 1,240,190 sq km
Capital: Bamako
Density of population: 12 persons per sq km
Life expectancy at birth: 49 years
Adult literacy rate: 19%
GNI Per Capita: $330
Urban population: 35%
Currency: CFA franc
Language: French

Malta

Population: 405,255
Land area: 320 sq km
Capital: Valletta
Density of population: 1266 persons per sq km
Life expectancy at birth: 79 years

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Adult literacy rate: 88%
GNI Per Capita: $12,050
Urban population: 93%
Capital: Valletta
Currency: Lira (plural liri)
Language: Maltese and English

Martinique

Population: 398,641
Land area: 1,102 sq km
Capital: Fort-de-France
Density of population: 362 persons per sq km
Life expectancy at birth: 79 years
Literacy rate: 98%
Urban population: 97%
Currenncy: Euro
Language: French

Mauritania

Population: 3,247,407
Land area: 1,025,520 sq km
Capital: Nouakchott
Density of population: 3 persons per sq km
Life expectancy at birth: 54 years
Adult literacy rate: 51%
GNI Per Capita: $530
Urban population: 67%
Currency: Ouguiya
Language: Arabic and French

Mauritius

Population: 1,266,964
Land area: 2040 sq km
Capital: Port Louis
Density of population: 621 persons per sq km
Life expectancy at birth: 73 years
Adult literacy rate: 84%
GNI Per Capita: $4640
Urban population: 44%
Population living under one dollar per day: 25.9 %
Currency: Rupee
Language: English and French

Mexico

Population: 109,594,066
Land area: 1,958,200 sq km
Capital: Mexico City
Density of population: 56 persons per sq km
Life expectancy at birth: 76 years
Adult literacy rate: 90%
GNI Per Capita: $6790
Urban population: 77%
Currency: New Peso
Language: Spanish

Micronesia

Population: 111,873
Land area: 700 sq km
Capital: Palikir
Density of population: 160 persons per sq km
Life expectancy at birth: 68 years
GNI Per Capita: $2300
Urban population: 31%
Currency: US dollar
Language: Kosraean, Yapese, Pohnpeian, Trukese, and English

Moldova

Population: 4,185,546
Land area: 33,850 sq km
Capital: Chisinau
Density of population: 124 persons per sq km
Life expectancy at birth: 70 years
Adult literacy rate: 96%
GNI Per Capita: $720
Urban population: 47%
Population living under one dollar per day: 22%
Currency: Moldovan lei
Language: Moldovan

Monaco

Population: 36,070
Land area: 2 sq km
Capital: Monaco
Density of population: 18,035 persons per sq km
Life expectancy at birth: 80 years
Adult literacy rate: 99%
Urban population: 100%
Currency: Euro
Language: French

Mongolia

Population: 2,711,496
Land area:1,566,500 sq km
Capital: Ulanbator
Density of population: 2 persons per sq km
Life expectancy at birth: 68 years
Adult literacy rate: 98%

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GNI Per Capita: $600
Urban population: 57%
Population living under one dollar per day: 27%
Currency: Tughrik
Language: Khalkha Mongolian

Montenegro

Population: 630,548
Land area: 14,026 sq km
Density of population: 46 persons per sq km
Urban population: 100%
Currency: Euro
Language: Serb

Montserrat

Population: 4,718
Land area: 102 sq km
Capital: Playmouth
Density of population: 46 persons per sq km
Urban population: 100%
Capital: Playmouth
Currency: EC dollar
Language: English

Morocco

Population: 32,412,175
Land area: 446,550 sq km
Capital: Rabat
Density of population: 73 persons per sq km
Life expectancy at birth: 71 years
Adult literacy rate: 51%
GNI Per Capita: $1570
Urban population: 60%
Currency: Dirham
Language: Arabic

Mozambique

Population: 20,522,462
Land area: 801,590 sq km
Capital: Maputo
Density of population: 26 persons per sq km
Life expectancy at birth: 42 years
Adult literacy rate: 46%
GNI Per Capita: $270
Urban population: 40%
Population living under one dollar per day: 38%
Currency: Metical
Language: Portuguese

Myanmar

Population: 51,474,684
Land area: 676,580 sq km
Capital: Pyiamna
Density of population: 76 persons per sq km
Life expectancy at birth: 62 years
Adult literacy rate: 90%
Urban population: 32%
Currency: Kyat
Language: Burmese

Namibia

Population: 2,072,298
Land area: 824,290 sq km
Capital: Windhoek
Density of population: 3 persons per sq km
Life expectancy at birth: 46 years
Adult literacy rate: 85%
GNI Per Capita: $2380
Urban population: 35%
Currency: Namibian
Language: English

Naura

Population: 14,028
Land area: 21 sq km
Capital: No official capital
Density of population: 668 persons per sq km
Urban population: 100%
Currency: Australian dollar
Language: English

Nepal

Population: 28,225,533
Land area: 147,180 sq km
Capital: Kathmandu
Density of population: 192 persons per sq km
Life expectancy at birth: 64 years
Adult literacy rate: 49%
GNI Per Capita: $250
Urban population: 17%
Population living under one dollar per day: 24%
Currency: Rupee
Language: Nepali

Netherlands

Population: 16,438,993

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Land area: 41,530 sq km
Capital: Amsterdam
Density of population: 396 persons per sq km
Life expectancy at birth: 79 years
Adult literacy rate: 100%
GNI Per Capita: 32,130
Urban population: 68%
Currency: Euro
Language: Dutch

Netherlands Antilles

Population: 185,262
Land area: 800 sq km
Capital: Willemstad
Density of population: 232 persons per sq km
Life expectancy at birth: 77 years
Adult literacy rate: 95%
GNI Per Capita : $32,130
Urban population: 71%
Currency: Netherlands Antillean guilder
Language: Dutch

New Zealand

Population; 4,092,625
Land area: 270,530 sq km
Capital: Wellington
Density of population: 15 persons per sq km
Life expectancy at birth: 80 years
Adult literacy rate: 99%
GNI Per Capita: $19,990
Urban population: 86%
Currency: NZ dollar
Language: English and Maori

Nicaragua

Population: 5,715,182
Land area: 130,000 sq km
Capital: Managua
Density of population: 44 persons per sq km
Life expectancy at birth: 71 years
Adult literacy rate: 77%
GNI Per Capita: $830
Urban population: 59%
Population living under one dollar per day: 45%
Currency: Cordoba
Language: Spanish

Niger

Population: 14,907,165
Land area: 1,267,000 sq km
Capital: Niamey
Density of population: 12 persons per sq km
Life expectancy at birth: 45 years
Adult literacy rate: 14%
GNI Per Capita: $210
Urban population: 24%
Population living under one dollar per day: 60.6%
Currency: CFA franc
Language: French

Nigeria

Population: 137,243,298
Land area: 923,770 sq km
Capital: Abuja
Density of population: 149 persons per sq km
Life expectancy at birth: 44 years
Adult literacy rate: 67%
GNI Per Capita: $430
Urban population: 50%
Population living under one dollar per day: 70.8%
Currency: Naira
Language: English

Northern Marianas

Population: 85,001
Land area: 500 sq km
Capital: Saipan
Density of population: 170 persons per sq km
Currency: US dollar
Language: English

Norway

Population: 4,664,619
Land area: 323,880 sq km
Capital: Oslo
Density of population: 14 persons per sq km
Life expectancy at birth: 80 years
Adult literacy rate: 100%
GNI Per Capita: $51,810
Urban population: 82%
Currency: Kroner
Language: Norwegian

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Oman

Population: 2,668,292
Land area: 309,500 sq km
Capital: Muscat (Masqat)
Density of population: 9 persons per sq km
Life expectancy at birth: 75 years
Adult literacy rate: 74%
GNI Per Capita: $9070
Urban population: 80%
Currency: Omani rial
Language: Arabic

Pakistan

Population:164,593,770
Land area: 796,100 sq km
Capital: Islamabad
Density of population: 207 persons per sq km
Life expectancy at birth: 65 years
Adult literacy rate: 50%
GNI Per Capita: $600
Urban population: 36%
Population living under one dollar per day: 17%
Currency: Rupee
Language: Urdu

Palau

Population: 20,174
Land area: 460 sq km
Capital: Koror
Density of population: 44 persons per sq km
Currency: US dollar
Language: English

Palestine/Filestin

Population: 3,945,139
Land area: 6,220 sq km
Capital: Jerusalem (Al-Quds)
Density of population: 634 persons per sq km
Life expectancy at birth: 73 years
Adult literacy rate: 92%
GNI Per Capita: $1120
Urban population: 73%
Currency: New Shekel
Language: Arabic

Panama

Population: 3,343,374
Land area: 75,520 sq km
Capital: Panama City
Density of population: 44 persons per sq km
Life expectancy at birth: 76 years
Adult literacy rate: 92%
GNI Per Capita: $4210
Urban population: 58%
Currency: Balboa
Language: Spanish

Papua New Guinea

Population: 6,114,223
Land area: 462, 840 sq km
Capital: Port Moresby
Density of population: 13 persons per sq km
Life expectancy at birth: 57 years
Adult literacy rate: 57%
GNI Per Capita: $560
Urban population: 13%
Currency: Kina
Language: English

Paraguay

Population: 6,444,836
Land area: 406,750 sq km
Capital: Asuncion
Density of population: 16 persons per sq km
Life expectancy at birth: 72 years
Literacy rate: 92%
Urban population: 60%
GNI Per Capita: $1140
Population living under one dollar per day: 16.4 %
Currency: Guarani
Language: Spanish and Guarani

Peru

Population: 28,797,346
Land area: 1,285,220 sq km
Capital: Lima
Density of population: 22 persons per sq km
Life expectancy at birth: 71 years
Adult literacy rate: 88%
GNI Per Capita: $2360
Urban population: 75%
Population living under one dollar per day: 12.5%
Currency: Nuevo Sol
Language: Spanish, Quechua and Aymara

Philippines

Population: 85,884,014
Land area: 300,000 sq km
Capital: Manila

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Density of population: 286 persons per sq km
Life expectancy at birth: 72 years
Adult literacy rate: 93%
GNI Per Capita: $1170
Urban population: 64%
Population living under one dollar per day: 15.5%
Currency: Peso
Language: Filipino and English

Pitcairn

Population: 67
Land area: 5 sq km
Capital: Adamstown
Density of population: 13 persons per sq km
Currency: NZ dollar
Language: English

Poland/Polska

Population: 38,466,661
Land area: 323,250 sq km
Capital: Warsaw (Warzawa)
Density of population: 119 persons per sq km
Life expectancy at birth: 75 years
Adult literacy rate: 98%
GNI Per Capita: $6100
Urban population: 62%
Currency: Zloty
Language: Polish

Portugal

Population: 10,592,716
Land area: 91,980 sq km
Capital: Lisbon
Density of population: 115 persons per sq km
Life expectancy at birth: 78 years
Adult literacy rate: 99%
GNI Per Capita: $14,220
Urban population: 57%
Currency: Euro
Language: Portuguese

Puerto Rico

Population: 3,997,981
Land area: 8,950 sq km
Capital: San Juan
Density of population: 447 persons per sq km
Life expectancy at birth: 77 years
GNI Per Capita: $10950
Urban population: 98%
Currency: US dollar
Language: Spanish and English

Qatar

Population: 857,492
Land area: 11,000 sq km
Capital: Doha (Ad-Dawhah)
Density of population: 78 persons per sq km
Life expectancy at birth: 74 years
Adult literacy rate: 89%
GNI Per Capita: $10150
Urban population: 93%
Currency: Riyal
Language: Arabic

Reunion

Population: 807,163
Land area: 2,510 sq km
Capital: Saint Denis
Density of population: 322 persons per sq km
Life expectancy at birth: 76 years
Urban population: 93%
Currency: Euro
Language: French

Romania

Population: 21,544,195
Land area: 238,390 sq km
Capital: Bucharest
Density of population: 90 persons per sq km
Life expectancy at birth: 72 years
Adult literacy rate: 97%
GNI Per Capita: $2960
Urban population: 55%
Currency: Lei
Language: Romanian

Russia

Population: 141,900,445
Land area: 17,075,400 sq km
Capital: Moscow (Moskva)
Density of population: 90 persons per sq km
Life expectancy at birth: 65 years
Adult literacy rate: 99%
GNI Per Capita: $3400
Urban population: 73%
Currency: Ruble
Language: Russian

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Rwanda

Population: 9,441,767
Land area: 26,340 sq km
Capital: Kigali
Density of population: 358 persons per sq km
Life expectancy at birth: 45 years
Adult literacy rate: 64%
GNI Per Capita: $210
Urban population: 25%
Currency: Rwandan Franc (RWF)
Population living under one dollar per day: 51.7%
Language: Kinyarwanda, English and French

St. Helena

Population: 5,019
Land area: 122 sq km
Capital: Jamestown
Density of population: 41 persons per sq km
Currency: Pound Sterling
Language: English

St. Kitts and Nevis

Population: 43,654
Land area: 360 sq km
Capital: Basseterre
Density of population: 121 persons per sq km
Currency: EC dollar
Language: English

St. Lucia

Population: 163,434
Land area: 620 sq km
Capital: Castries
Density of population: 264 persons per sq km
Life expectancy at birth: 73 years
Urban population: 32%
Currency: EC dollar
Language: English

St. Vincent and Grenadines

Population: 120,267
Land area: 390 sq km
Capital: Kingstown
Density of population: 24 persons per sq km
Life expectancy at birth: 72 years
Currency: EC dollar
Language: English

Samoa

Population; 186,983
Land area; 2,840 sq km
Capital: Apia
Density of population: 66 persons per sq km
Life expectancy at birth: 71 years
Adult literacy rate: 99%
GNI Per Capita: $1840
Urban population: 23%
Currency: Tala
Language: Samoan and English

Samoa, American

Population: 67,610
Land area: 200 sq km
Capital: Pago Pago
Density of population: 338 persons per sq km
Currency: US dollar
Language: Samoan and English

San Marino

Population: 28,562
Land area; 61 sq km
Capital: San Marino
Density of population: 468 persons per sq km
Currency: Euro
Language: Italian

Sao Tome and Principe

Population: 163,656
Land area: 960 sq km
Capital: Sao Tome
Density of population: 170 persons per sq km
Life expectancy at birth: 64 years
Urban population: 38%
Currency: Dobra
Language: Portuguese

Saudi Arabia

Population: 25,809,195
Land area: 2,149,690 sq km
Capital: Riyadh
Density of population: 12 persons per sq km
Life expectancy at birth: 73 years
Adult literacy rate: 79%
GNI Per Capita: $10140
Urban population: 89%

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Currency: Saudi Arabian Riyal
Language: Arabic

Senegal

Population: 12,217,706
Land area: 196,720 sq km
Capital: Dakar
Density of population: 62 persons per sq km
Life expectancy at birth: 57 years
Adult literacy rate: 39%
GNI Per Capita: $610
Urban population: 52%
Population living under one dollar per day: 22.3%
Currency: CFA franc
Language: French

Serbia

Population: 9,396,411
Land area: 88,361 sq km
Capital: Belgrade
Density of population: 103 persons per sq km
Life expectancy at birth: 74 years
Adult literacy rate: 96%
GNI Per Capita: $2680
Urban population: 53%
Currency: Serb Dinar
Language: Serb

Seychelles

Population: 82,087
Land area: 450 sq km
Capital: Victoria
Density of population: 182 persons per sq km
Adult literacy rate: 92%
GNI Per Capita: $8190
Currency: Rupee
Language: English and French

Sierra Leone

Population: 5,802,221
Land area: 71,740 sq km
Capital: Freetown
Density of population: 81 persons per sq km
Life expectancy at birth: 42 years
Adult literacy rate: 30%
GNI Per Capita: $210
Urban population: 42%
Currency: Leone
Language: English

Singapore

Population: 4,433,808
Land area: 620 sq km
Capital: Singapore
Density of population: 7151 persons per sq km
Life expectancy at birth: 79 years
Adult literacy rate: 93%
GNI Per Capita: $24760
Urban population: 100%
Currency: Singapore dollar
Language: Malay and English

Slovakia

Population: 5,400,676
Land area: 49,010 sq km
Capital: Bratislava
Density of population: 110 persons per sq km
Life expectancy at birth: 75 years
Adult literacy rate: 100%
GNI Per Capita: $6480
Urban population: 59%
Currency: Koruny
Language: Slovak

Slovenia

Population: 1,964,723
Land area: 20,250 sq km
Capital: Ljubljana
Density of population: 97 persons per sq km
Life expectancy at birth: 77 years
Adult literacy rate: 100%
GNI Per Capita: $14,770
Urban population: 51%
Currency: Euro
Language: Slovenian

Solomon Islands

Population: 501,685
Land area: 28,900 sq km
Capital: Honiara
Density of population: 17 persons per sq km
Life expectancy at birth: 63 years
GNI Per Capita: $560
Urban population: 18%
Currency: Soloman Islands dollar
Language: English

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Somalia

Population: 8,766,320
Land area: 637,660 sq km
Capital: Mogadishu
Density of population: 14 persons per sq km
Life expectancy at birth: 49 years
Adult literacy rate: 60%
GNI Per Capita: $110
Urban population: 37%
Currency: Shilling
Language: Somali and Arabic

South Africa

Population: 47,698,677
Land area: 1,221,040 sq km
Capital: Tshwane (Pretoria)
Density of population: 39 persons per sq km
Life expectancy at birth: 44 years
Adult literacy rate: 82%
GNI Per Capita: $3630
Urban population: 59%
Population living under one dollar per day: 10.7%
Currency: Rands
Language: Afrikans, English+ nine African Languages

Spain

Population: 43,604,345
Land area: 505,990 sq km
Capital: Madrid
Density of population: 86 persons per sq km
Life expectancy at birth: 80 years
Adult literacy rate: 99%
GNI Per Capita: $21,530
Urban population: 77%
Currency: Euro
Language: Spanish

Sri Lanka

Population: 21,077,941
Land area: 65,610 sq km
Capital: Colombo
Density of population: 321 persons per sq km
Life expectancy at birth: 75 years
Adult literacy rate: 90%
GNI Per Capita: $1010
Urban population: 21%
Currency: Rupee
Language: Sinhalese

Sudan

Population: 37,792,985
Land area: 2,505,810 sq km
Capital: Khartoum
Density of population:15 persons per sq km
Life expectancy at birth: 57 years
Adult literacy rate: 59%
GNI Per Capita: $530
Urban population: 43%
Currency: Pound
Language: Arabic

Surinam

Population: 454,606
Land area: 163,270 sq km
Capital: Paramaribo
Density of population: 3 persons per sq km
Life expectancy at birth: 70 years
Adult literacy rate: 88%
Urban population: 78%
GNI Per Capita: $2230
Currency: Surinamese dollar
Language: Dutch

Swaziland

Population; 1,025,207
Land area: 17,360 sq km
Capital: Mbabane
Density of population: 59 persons per sq km
Life expectancy at birth: 30 years
Adult literacy rate: 79%
GNI Per Capita: $1660
Urban population: 24%
Currency: Emalangeni
Language: English

Sweden/Sverige

Population: 9,095,374
Land area; 449,960 sq km
Capital: Stockholm
Density of population: 20 persons per sq km
Life expectancy at birth: 81 years
Adult literacy rate: 100%
GNI Per Capita: $35,840
Urban population: 84%
Currency: Kronor
Language: Swedish

Switzerland

Population: 7,274,524 sq km

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Land area: 41,290 sq km
Capital: Bern
Density of population: 176 persons per sq km
Life expectancy at birth: 81 years
Adult literacy rate: 100%
GNI Per Capita: $49,600
Urban population: 68%
Currency: Swiss franc
Language: German, French and Italian

Syria

Population: 19,988,028
Land area: 185,180 sq km
Capital: Damascus (Dimashq)
Density of population: 108 persons per sq km
Life expectancy at birth: 74 years
Adult literacy rate: 73%
GNI Per Capita: $1230
Urban population: 51%
Currency: Pound
Language: Arabic

Tajikistan/Tojikiston

Population: 6,681,503
Land area: 143,100 sq km
Capital: Dushanbe
Density of population: 47 persons per sq km
Life expectancy at birth: 64 years
Adult literacy rate: 99%
GNI Per Capita: $280
Urban population: 24%
Currency: Ruble
Language: Tajik

Tanzania

Population: 39,717,974
Land area; 945,090 sq km
Capital: Dodoma
Density of population: 42 persons per sq km
Life expectancy at birth: 47 years
Adult literacy rate: 69%
GNI Per Capita: $320
Urban population: 40%
Population living under one dollar per day: 57.8%
Currency: Shilling
Language: Swahili and English

Thailand

Population: 65,282,969
Land area: 513,120 sq km
Capital: Bangkok
Density of population: 127 persons per sq km
Life expectancy at birth: 72 years
Adult literacy rate: 93%
GNI Per Capita: $2490
Urban population: 33%
Currency: Baht
Language: Thai or Siamese

Timor Leste

Population: 1,067,907
Land area; 14,870 sq km
Capital: Dili
Life expectancy at birth: 56 years
Currency: Indonesian rupiah
Language: Tetum

Togo

Population: 6,470,249
Land area: 56,790 sq km
Capital: Lome
Density of population: 114 persons per sq km
Life expectancy at birth: 56 years
Adult literacy rate: 53%
GNI Per Capita: $310
Urban population: 38%
Currency: CFA franc
Language: French

Tonga

Population: 102,852
Land area: 750 sq km
Capital: Nuku'alofa
Density of population: 137 persons per sq km
Life expectancy at birth: 73 years
Adult literacy rate: 99%
GNI Per Capita: $1860
Urban population: 35%
Currency: Pa'anga
Language: Tongan and English

Trinidad and Tobago

Population: 1,312,854
Land area: 5,130 sq km
Capital: Port of Spain
Density of population: 256 persons per sq km
Life expectancy at birth: 70 years
Adult literacy rate: 98%
GNI Per Capita: $8730
Urban population: 77%
Currency: Trinidad dollar
Language: English

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Tunisia

Population: 10,318,640
Land area: 163,610 sq km
Capital: Tunis
Density of population: 63 persons per sq km
Life expectancy at birth: 74 years
Adult literacy rate: 74%
GNI Per Capita: $2650
Urban population: 65%
Currency: Dinar
Language: Arabic

Turkey

Population: 75,160,745
Land area: 774,820 sq km
Capital: Ankara
Density of population: >7 persons per sq km
Life expectancy at birth: 70 years
Adult literacy rate: 88%
GNI Per Capita: $3750
Urban population: 68%
Currency: Lire
Language: Turkish

Turkmenistan

Population: 4,965,275
Land area: 488,100 sq km
Capital: Ashkhabad
Density of population: 10 persons per sq km
Life expectancy at birth; 63 years
Adult literacy rate: 99%
GNI Per Capita: $750
Urban population: 46%
Currency: Manat
Language: Turkmen

Turks and Caicos

Population: 27,528
Land area: 430 sq.km.
Capital: Cockburn Town
Density of population: 64 persons per sq km
Currency: US dollar
Language: English

Tuvalu

Population: 10,530
Land area: 26 sq km
Capital: Fongafale
Density of population: 405 persons per sq km
Currency: Australian dollar
Language: Tuvaluan and English

Uganda

Population: 30,945,464
Land area: 241,040 sq km
Capital: Kampala
Density of population: 128 persons per sq km
Life expectancy at birth: 52 years
Adult literacy rate: 69%
GNI Per Capita: $250
Urban population: 13%
Currency: Shilling
Language: English, Luganda

Ukraine

Population: 45,509,182
Land area: 603,700 sq km
Capital: Kiev (Kyiv)
Density of population: 75 persons per sq km
Life expectancy at birth: 66 years
Adult literacy rate: 99%
GNI Per Capita: $1270
Urban population: 68%
Currency: Grivna
Language: Ukranian

United Arab Emirates

Administrative Divisions: Seven Emirates, namely, Abu-Dhabi, Ajman, Dubai, Fujairah, Ras-al-Khaimah, Sharjah and Umm-al-Qaiwain,
Population: 4,775,260
Land area: 83,600 sq km
Capital: Abu Dhabi
Density of population: 57 persons per sq km
Life expectancy at birth: 79 years
Adult literacy rate: 77%
GNI Per Capita: $23,770
Urban population: 86%
Currency: Dirham
Language: Arabic

United Kingdom

Population: 60,018,293
Land area: 242,910 sq km
Capital: London
Density of population: 247 persons per sq km
Life expectancy at birth: 79 years
Adult literacy rate: 100%
GNI Per Capita: $33,630

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Urban population: 89%
Currency: Pound Sterling
Language: English

United States

Population: 303,851,231
Land area: 9,629,090 sq km
Capital: Washington D.C.
Density of population: 32 persons per sq km
Life expectancy at birth: 79 years
Adult literacy rate: 99%
GNI Per Capita: $41,440
Urban population: 81%
Currency: Dollar
Language: English

Uruguay

Population: 3,509,373
Land area: 176,220 sq km
Capital: Montevideo
Density of population: 20 persons per sq km
Life expectancy at birth: 76 years
Adult literacy rate: 98%
GNI Per Capita: $3900
Urban population: 93%
Currency: Peso
Language: Spanish

Uzbekistan

Population: 27,371,291
Land area: 447,400 sq km
Capitak: Tashkent
Density of population: 61 persons per sq km
Life expectancy at birth: 67 years
Adult literacy rate: 99%
GNI Per Capita: $450
Urban population: 36%
Currency: Som-Kupon
Language: Uzbek

Vanuatu

Population: 219,465
Land area: 12,190 sq km
Capital: Vila
Density of population: 18 persons per sq km
Life expectancy at birth: 70 years
Adult literacy rate: 74%
GNI Per Capita: $1390
Urban population: 25%
Currency: Vatu
Language: Bislama, English and French

Vatican City

Population: 932
Land area: 0.44 sq km
Capital: Vatican City
Density of population: 1780 persons per sq km
Currency: Euro
Language: Italian and Latin

Venezuela

Population: 27,683,617
Land area: 912,050 sq km
Capital: Caracas
Density of population: 30 persons per sq km
Life expectancy at birth: 74 years
Adult literacy rate: 93%
GNI Per Capita: $4030
Urban population: 89%
Currency: Bolivar
Language: Spanish

Vietnam

Population: 86,444,718
Land area: 331,690 sq km
Capital: Hanoi
Density of population: 261 persons per sq km
Life expectancy at birth: 72 years
Adult literacy rate: 90%
GNI Per Capita: $540
Urban population: 28%
Currency: Dong
Language: Vietnamese

Virgin Island (US)

Population: 111,823
Land area: 340 sq km
Capital: Charlotte Amalie
Density of population: 329 persons per sq km
Life expectancy at birth: 79 years
Urban population: 95%
Currency: US dollar
Language: English

Virgin Island (British)

Population: 22,545
Land area: 153 sq km
Capital: Road Town
Density of population: 147 persons per sq km
Currency: US dollar
Language: English

Western Sahara

Population: 372,357

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Land area: 266,000 sq km
Capital: El Aaiun
Density of population: 1 person per sq km
Life expectancy at birth: 66 years
Adult literacy rate: 65%
Urban population: 94%
Currency: Moroccan dirham
Language: Arabic and Spanish

West Papua

Population: 1,800,000
Land area: 418,000 sq km
Capital: Jayapura
Density of population: 13 persons per sq km
Life expectancy at birth: 57 years
Urban population: 13%
Currency: Indonesian rupiah
Language: 250 living languages, Bahasa Indonesia

Yemen/Al Yaman

Population: 22,324,994
Land area: 527,970 sq km
Capital: Sana'a
Density of population: 42 persons per sq km
Life expectancy at birth: 63 years
Adult literacy rate: 49%
GNI Per Capita: $550
Urban population: 27%
Population living under one dollar per da : 15.7%
Currency: Rial
Language: Arabic

Zambia

Population: 12,056,046
Land area: 752,610 sq km
Capital: Lusaka
Density of population: 16 persons per sq km
Life expectancy at birth: 39 years
Adult literacy rate: 68%
Urban population: 37%
Currency: Kwacha
Language: English

Zimbabwe

Population: 13,162,065
Land area: 390,760 sq km
Capital: Harare
Density of population: 34 persons per sq km
Life expectancy at birth: 37 years
Adult literacy rate: 90%
Urban population: 37%
Currency: Zimbabwe dollar
Language: English

***Table 6.42:** Major Agencies of United Nations*

INTRAW	International Research and Training Institute for Advancement of Women
UNICEF	United Nations Children's Fund (Head Quarters: New York)
UPU	Universal Postal Union (H.Q. Bern)
IBRD	International Bank for Reconstruction and Development (H.Q. Washington, D.C.)
UNTSO	United Nations Truce Supervision Organisation
UNESCO	United Nations Educational, Scientific and Cultural Organisation (H.Q. Paris)
UNCTAD	United Nations Conference on Trade and Development
UNIDO	United Nations Industrial Development Organisation (H.Q. Vienna)
IFAD	International Fund for Agricultural Development (H.Q. Rome)
ICAO	International Civil Aviation Organisation (H.Q. Montreal)
UNFPA	United Nations Fund for Population Activities (H.Q. New York)
IDA	International Development Association (H.Q. Washington)
UNITAR	United Nations Institute for Training and Research
UNU	United Nations University

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WMO	World Meteorological Organisation
WHO	World Health Organisation (H.Q. Geneva)
IFC	International Finance Corporation (H.Q. Washington, D.C.)
UNDP	United Nations Development Programme (H.Q. New York)
WFC	World Food Council
WFP	World Food Programme
IMO	International Maritime Organisation (H.Q. London)
ILO	International Labour Organisation (H.Q. Geneva)
IMF	International Monetary Fund (H.Q. Washington)
UNEP	United Nations Environmental Programme (H.Q. Nairobi)
IAEA	International Atomic Energy Agency (H.Q. Vienna)
FAO	Food & Agriculture Organisation (H.Q. Rome)
WIPO	World Intellectual Property Organisation (H.Q. Geneva)
ITU	International Telecommunication Union (H.Q. Geneva)

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Chapter Seven

World Economic Geography

Chapter Concepts

- Age and Dimensions of Earth
- Resource: Concept and Types
- Energy Resources
- Mineral Resources

Economic geography deals with the analysis of the spatial distribution of the transportation and consumption of resources, goods, and services, and their effect on landscape.

Resource: Concept and Types

Any thing that fulfills peoples needs is known as a resource. Resource may be natural, like mineral-ores, water, soil, natural vegetation, climate or man-made – labour, skills, finance, capital, technology and working environment. Resources may be classified into two categories, i.e. non-renewable and renewable resources.

Non-Renewable Sources

Mineral resources like coal, petroleum and natural gas are the exhaustible, non-renewable resources. They cannot be replaced once they are consumed. Coal and petroleum, the fossil fuels on which the modern culture relies so much, are non-renewable. These energy resources have been concentrated and preserved by geologic processes that operated over the vast periods of geologic time. Although the same processes may function today, they operate so slowly to replenish our supplies of these fuels.

Renewable Resources (Flow Resources)

A recurrent resource which is not diminished when used, but which will be restored. Examples include solar, tidal and wind energy. Renewable resources may be consumed without endangering future consumption as long as use does not outstrip production of new resources, as in fishing.

Energy Resources

Renewable energy resources

These are known as the alternate sources of energy. Renewable energy resources include solar energy, hydropower, bio mass, tidal, wind and geothermal energy. Together they cannot be expected to fulfill our energy needs. Nuclear energy may, however, become a major energy source to fulfill the shortage in the future.

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Modern society's technological progress and standard of living are intimately related to energy consumption. According to social scientists, the higher the energy consumption per head, the higher is the standard of living of the people. People all over the world are however, experiencing a serious energy shortage which may become more acute in future. In such a scenario, hydro-power and nuclear energy are the best alternate sources of energy.

Hydro-Power

Throughout the history water played an important role in the agricultural industrial and trade development of the world. Water is used for irrigation, industries, domestic purpose, nutrition, navigation and for the generation of hydro-electricity. Water became a major source of energy after the invention of water-power-generator in 1882. It has no capacity to produce energy within itself. Water creates power by its motion-usually by falling vertically. The greater the distance of fall, the greater the power potential. Typically, this potential occurs in upland areas or in mountainous environments with human-made dams.

At present, water power provides an important source of electricity in the world. Hydroelectricity, however, despite a clean source of energy, provides only 6.5 per cent of the total energy consumed in the world. About 99 per cent of the total energy requirement of Norway is obtained from water, while New Zealand, Switzerland obtain about 75 per cent of their power requirements from water. In South American countries also about 75 per cent of the total power is hydro- power.

Nuclear Energy

The nuclear energy production was started in the 1950s. Its production was started first in USA. At present over 60 nuclear reactors exist in USA. Most of these reactors are located in the highly urbanized regions of North-East USA. Other important producers of nuclear energy are France, Russia, Japan, Germany, Italy, Belarus, Poland, Romania, and Ukraine. After the Chernobyl (1986) and Fukishima (2011) nuclear tragedy it has been proved that it is the most risky form of energy.

Non-renewable Energy Resources

Oil (Petroleum), natural gas, coal, wood, solar water and uranium fill most of the world's energy requirements. All but wood, water, wind, tidal and solar are renewable while fossil fuels – coal, petroleum and natural gas are non-renewable sources of energy. In fact, all fossil fuels (coal, petroleum, natural gas), once used cannot be renewed.

Coal

Coal is abundant and cheap but exhaustible. The consumption of coal is more than 5 billion tons per year. In the developed countries of Europe, USA, Canada, Japan, Australia and New Zealand, each person consumes an equivalent of 5 tons or more coal in a year. Coal combustion, however, accounts for 35 per cent of worldwide carbon dioxide emissions .

There are four types of coal: (i) peat, (ii) lignite, (iii) bituminous, and (iv) anthracite. The physical and chemical properties of coal depends on the degrees of compression and or the depth of burial. Peat develops with the decay of plants in bogs. This process yields *peat*. Compressed *peat* yields *lignite*, a low grade coal, often called *brown coal*. When coal is buried deeply, moisture expelled and the material subjected to increased temperatures, a firmer *bituminous* coal results. It is most popular in metallurgy and referred as *soft coal*. Further compression yields *anthracite*, the highest quality hard coal. The high grade coal used in the steel industry is frequently called *coking coal*. It results from the heating of coal in the absence of oxygen, which burns off volatile gases.

The distribution of major coal deposits of the world have been shown in **Fig. 7.1** while, the main coal deposits of U.S.A., Europe and Russia have been plotted in **Figs.. 7.2** to **7.4.**, respectively. **Tables 7.1** and **7.2** shows the leading coal producing and coal consuming countries of the world.

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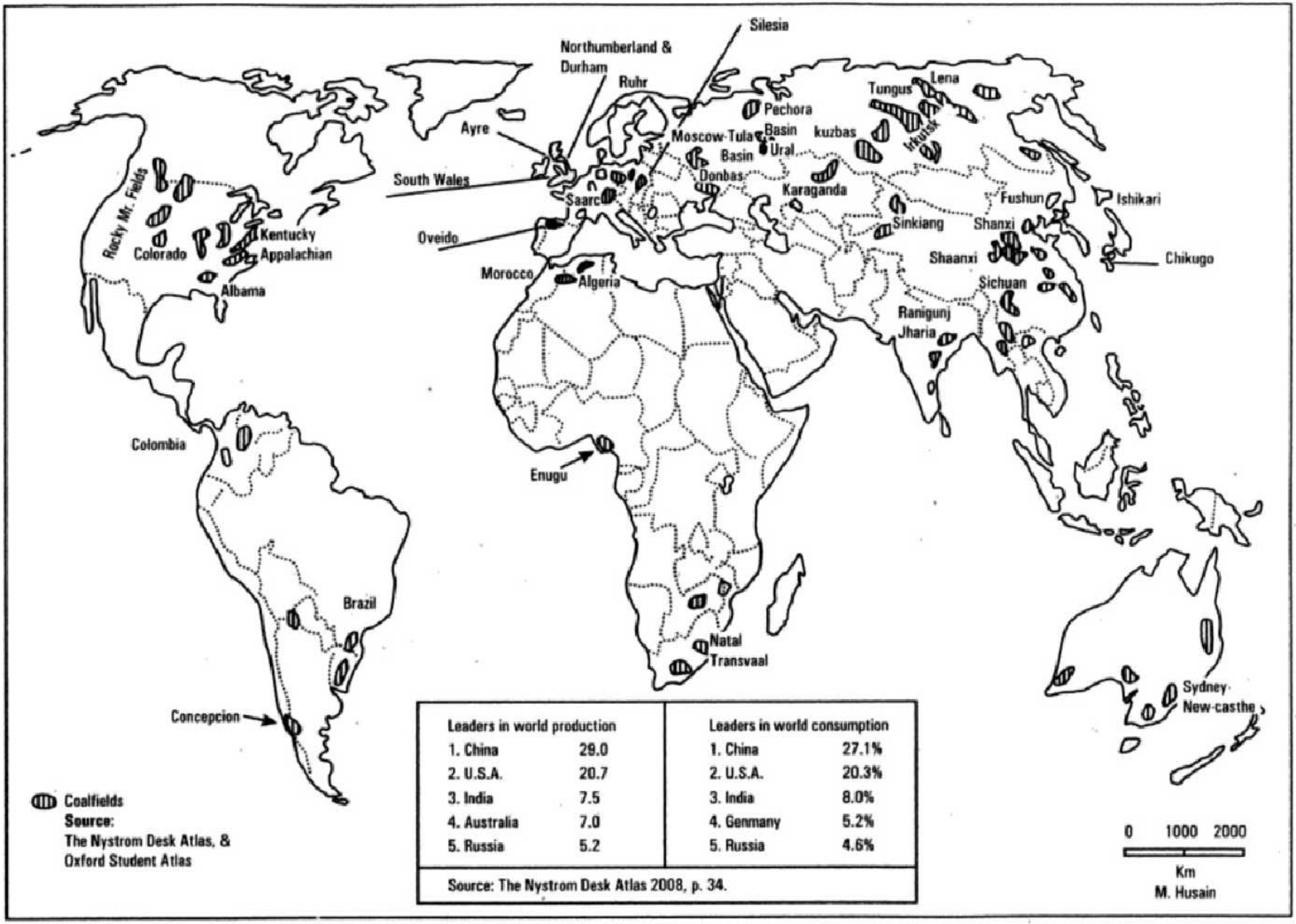

Leaders in world production		Leaders in world consumption	
1. China	29.0	1. China	27.1%
2. U.S.A.	20.7	2. U.S.A.	20.3%
3. India	7.5	3. India	8.0%
4. Australia	7.0	4. Genmany	5.2%
5. Russia	5.2	5. Russia	4.6%

Source: The Nystrom Desk Atlas 2008, p. 34.

Fig. 7.1 – World – Distribution of coal

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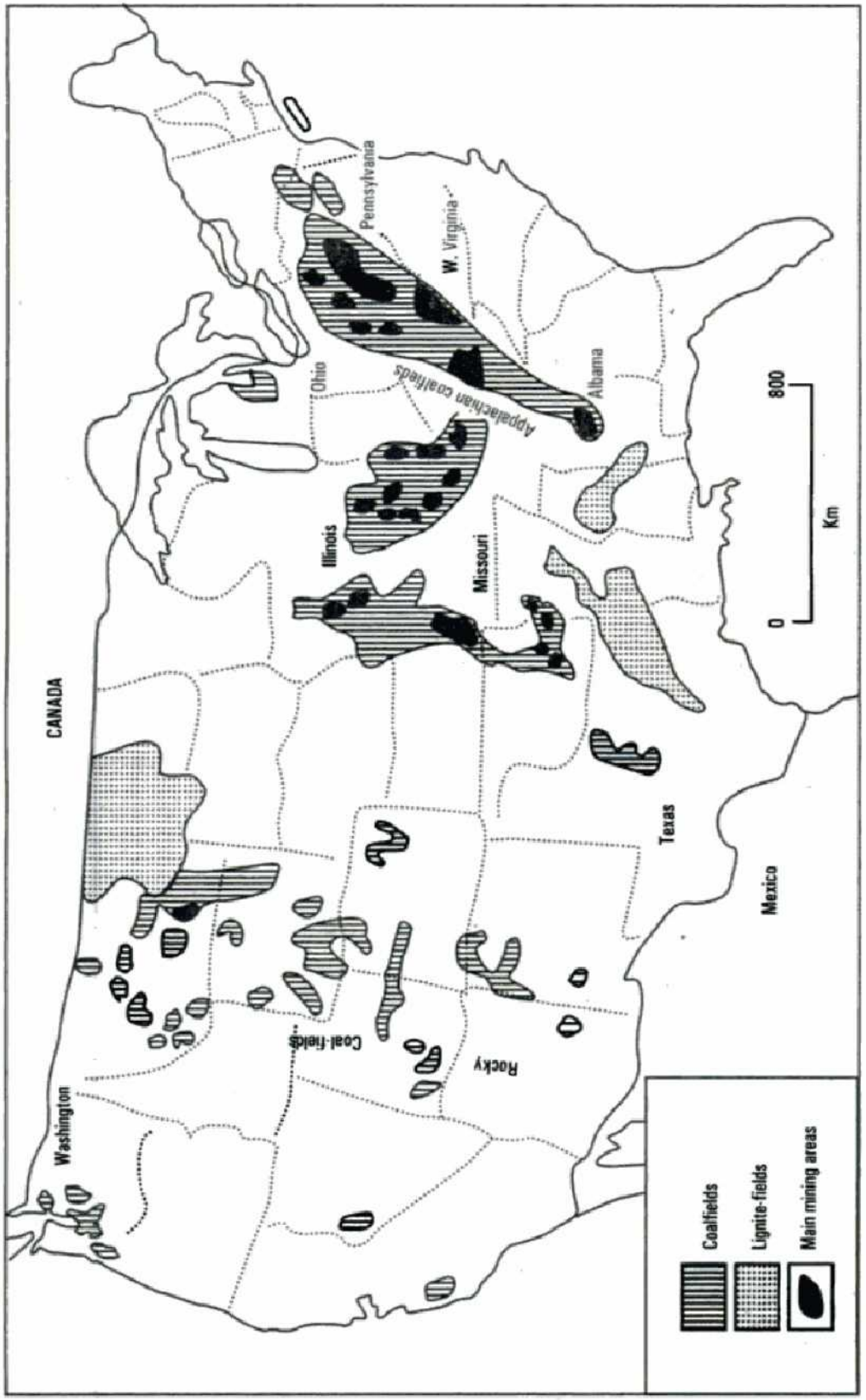

Fig. 7.2 – U.S.A. coalfields

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Table 7.1:– Coal – Leading Coal Producing Countries of the World

Country	Percentage of total production
1. China	29.0
2. U.S.A.	20.7
3. India	7.5
4. Australia	7.0
5. Russia	5.2

Table 7.2: Coal – Leading Consumers in the World

Country	Percentage of total consumption
1. China	27.1
2. U.S.A.	20.3
3. India	8.0
4. Germany	5.2
5. Russia	4.6

Table 7.3: Major Coalfields of the World

Country	Coal Mines
1. China	Shaanxi(Shansi), Shanxi (Shensi), Sichuan, Fushun, Shenyang, Sinkiang
2. USA	Arkansas, Colorado, Illinois, Indiana, Iowa, Kentucky, Michigan, Montana, New Mexico, North Dakota, Ohio, Oklahoma, Pennsylvania, Pittsburgh, West Virginia (Appalachian), Utah, Wyoming **(Fig. 7.2)**
3. India	Bokaro, Jharia, Karanpur, Neyvelli, Korba, Raniganj, Singreni, Singrauli, Talcher
4. Australia	Bowen Basin, Brisbane, Canberra, Sydney-New- Castle (New South Wales), Fingal (Tasmania), Ipswich (Queensland), Gippsland (Victoria), Pagingo
5. Russia	Moscow-Tula, Chokot Basin (Eastern Siberia), Irkutsk Basin, Lena Basin, Kizel, Komi-Ukhta (Pechora Basin), Kuznetsk (Kuzbas), northern and eastern Siberia, Irkutsk, Ob Basin, Sakhalin Island, Tungaska Basin, Tyumen (Ob Basin) Upper Lena, Vladivostok, Yakut Basin, Zyryanska Basin **(Fig. 7.3)**
6. Poland	Upper Silesian and Lower Silesian Fields **(Fig. 7.4)**

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7. Germany	Rhur, Saxony, Leipzig, Magdeburg, Dresden, Saar, Bavaria, Cologne **(Fig. 7.4)**
8. Great Britain	Cumberland, Durham, Derbyshire, Lancashire, Leicestershire, Northumberland, Nottinghamshire, South Wales, Warwickshire **(Fig. 7.4)**
9. Canada	Alberta, Vancouver (British Columbia)
10. France	Pas de Calais and Nord (North-Eastern France), Franco-Belgian Coalfields, Alsace-Lorraine Fields, Central Massif
11. Belgium	Franco-Belgian Coal-Fields, Campine Coalfields
12. Brazil	Southern Brazil
13. South Africa	Transvaal, Natal
14. Chile	Concepcion
15. Others	Argentina, Columbia, Nigeria, Peru

Japan is the leading importer of coal, the west European countries import about 34 per cent of the coal in the world. Over 50 per cent of the total import is done by Japan, West European countries and Canada import more than 60 per cent of the total coal trade in the world.

Oil (Petroleum)

Oil is the most efficient source of energy in the world today. Petroleum and natural gas and their products are the most important commodities in international trade today. It is a global industry, wherein prices are reported almost exclusively in international terms. South West Asia has the largest deposits of petroleum and natural gas. The first oil well was dug near *Titusville* (Pennsylvania) north of Pittsburg. Subsequently oil was found in Romania and Russia, near Caspian Sea-Baku (Azarbaijan). At present over 50 per cent of the oil is found in the countries of South-West Asia. The leading oil producing and oil consuming countries have been given in **Fig. 7.5**, while **Figs. 7.6 to 7.10** show the major oil deposits in South West Asia, U.S.A., Soviet Union, Europe and the North Sea, respectively.

The oil exporting countries raised the price of petroleum rapidly in 1974 which led to energy crisis in the world. The OPEC countries include 1. Angola, 2. Algeria, 3. Iran, 4. Iraq, 5. Kuwait, 6. Indonesia, 7. Libya, 8. Nigeria, 9. Qatar, 10. Saudi Arabia, 11. UAE, 12. Venezuela. The other oil exporting countries include Mexico and Russia **(Fig. 7.11).**

***Table 7.4** : Oil (Petroleum) – Leading Producers in the World*

Country	*Percentage of total production*
1. Saudi Arabia	12.3
2. Russia	11.7
3. United States	8.1
4. Iran	5.4
5. China	4.9

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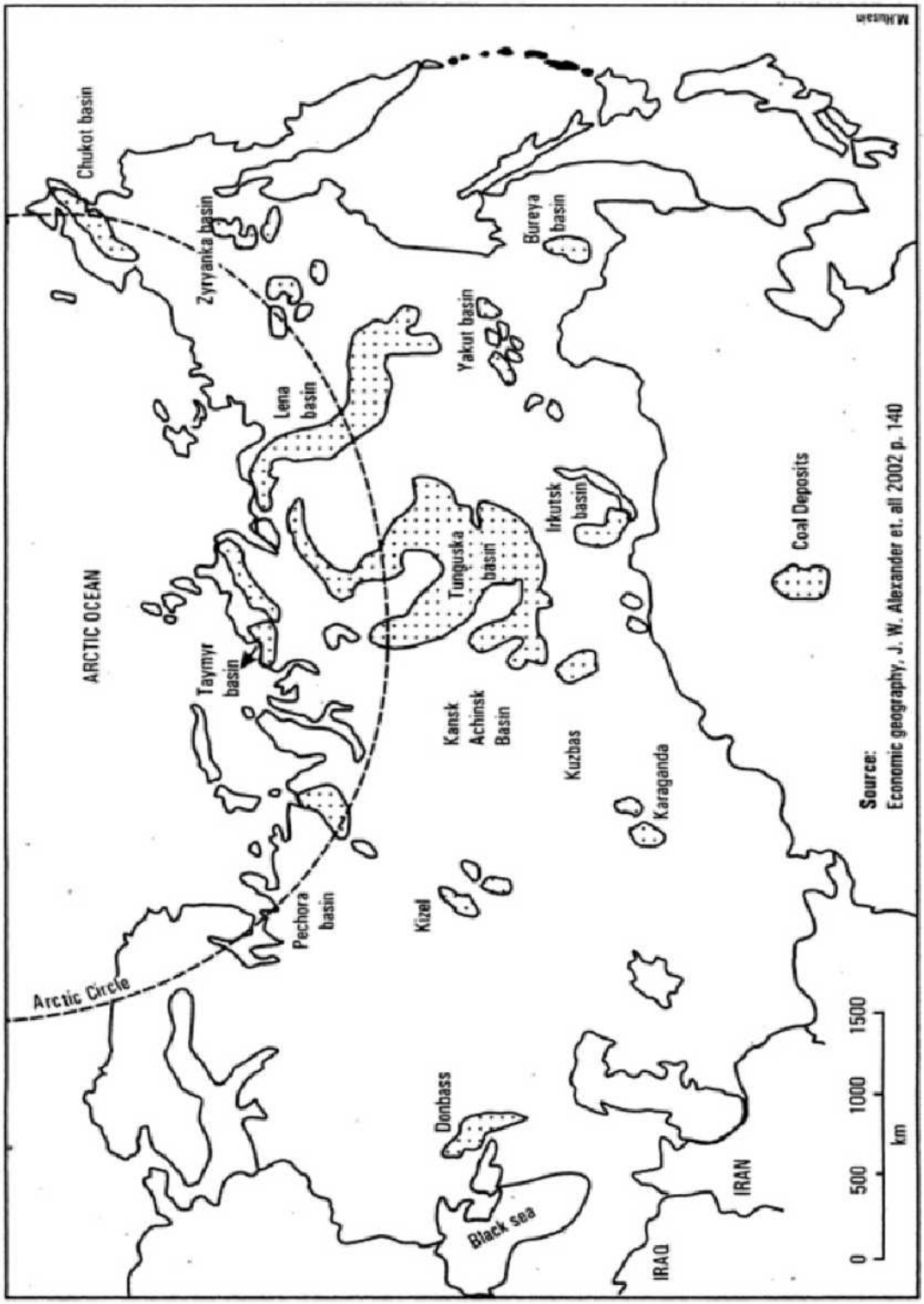

Fig. 7.3 – Russia coal deposits

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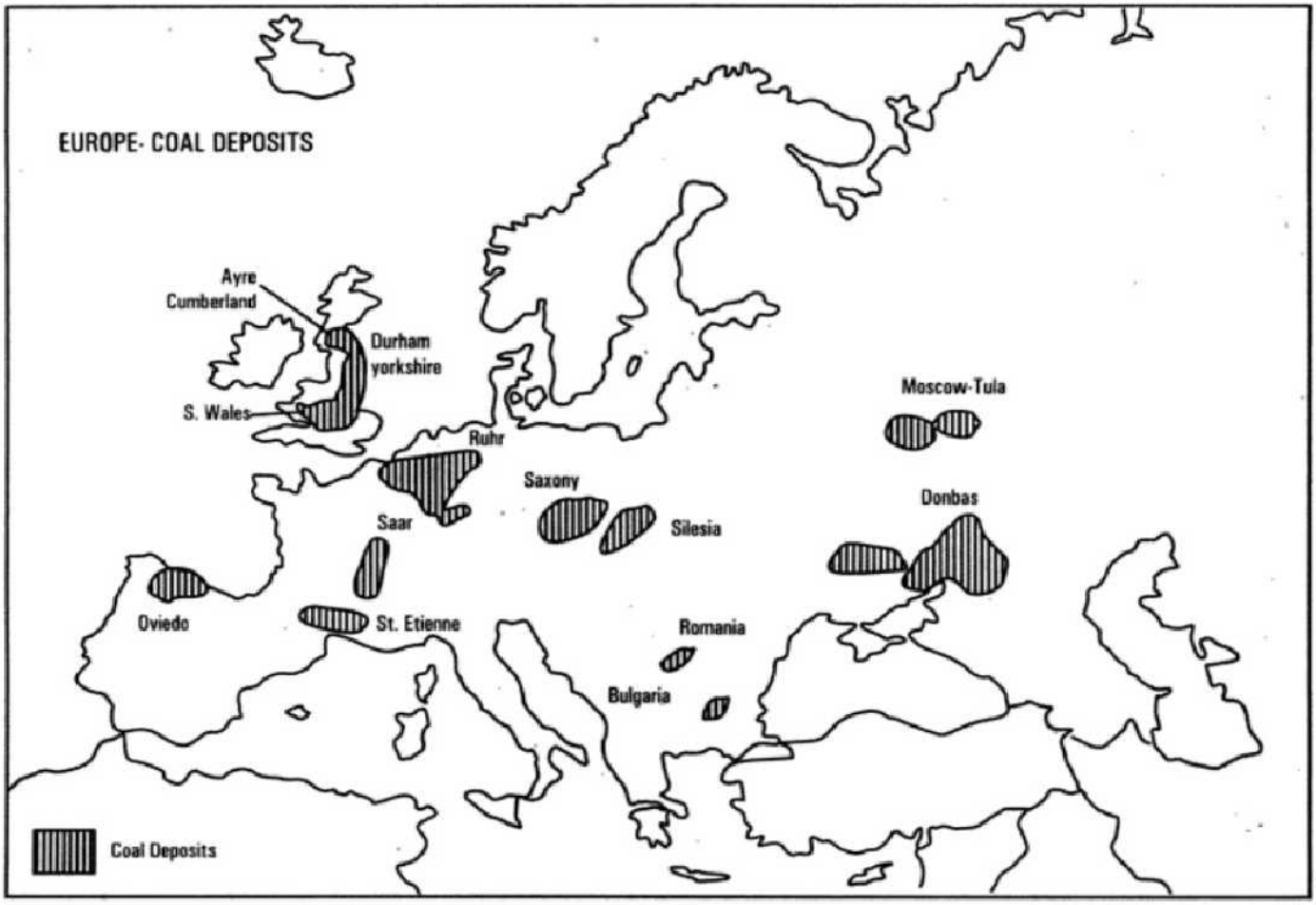

Fig. 7.4 – Europe coal deposits

***Table 7.5:** Oil (Petroleum) – Leading Consumers in the World*

Country	*Percentage of total consumption*
1. United States	25.2
2. Japan	7.0
3. China	6.6
4. Germany	3.5
5. Russia	3.3

***Table 7.6:** Major Petroleum Producing Centres*

Country	*Producing Centres*
Algeria	Bougie, Edjele,Hassi Massould, Hassi R'Mel,
Australia	Alice Spring (Northern Territory), Bass Starait, Moonie (Queensland), Daly Basin (Northern Territory), Port Hedland (Western Australia)
Brunei	Northern shore of Brunei
Brazil	Amazon Basin, Coastal Brazil

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Canada	Alberta, Athabaska, Saskatchewan
China	Daqing (Taching), Dakang (Takang), Shandong (Shantung), Panshan, Yumen, Karami in Xinjiang (Sinkiang), Kashi (Kashgar)
Egypt	Sinai Peninsula
India	Bombay High, Digboi, Gulf of Khambat, Upper Assam
Indonesia	Jambi, Minas, Palembang, Kalimantan (Borneo Island), Balikpapan
Iran	Agha-Jari, Bahregan, Lali, Masjid-i-Sulaiman
Iraq	Alwand, Basara, Kirkuk, Mosul
Libya	Marsa Brega, Zelten, Ras Sidar, Sirte Basin,Tobruk
Malaysia	Sarawak, east Coast of Peninsula of Malaysia.
Mexico	Cludad Madero, Poza Rica, Reynosa
Niger	Niger Delta
Russia	Bashkiria, Grozny, Kuybyshev, Maikop, Nizhnevartovsk, Perm, Sakhalin Island, Tataria, Tomsk
Saudi Arabia	Abqaiq, Ain Dar,Dahran, Ghawar, Jubail, Safania
U.K.	Northern Sea
U.S.A.	Alaska, Arkansas, California, Illinois, Kentucky, Lousiana, Michigan, New Mexico, Ohio, San Joaquin, Texas, Wayoming
Venezuela	Aruba, Lagunillas, Maracaibo Lake

The major exporters of oil and petroleum have been plotted in **Fig.7.11.** The oil exporting countries (OPEC) include: Angola, Algeria, Iran, Iraq, Kuwait, Indonesia, Libya, Nigeria, Qatar, Saudi Arabia, United Arab Emirates (UAE) and Venezuela. Among the other main oil exporting countries are Mexico and Russia.

Natural Gas: Natural gas is one of the important sources of energy. Natural gas burns clean andis easy to use, and relatively cheap to buy. Its storage and distribution is, however, complicated. It is found either separately or with crude oil. The leading natural gas producers and leading consumer countries have been shown in **Figs. 7.12.**

It may be seen from **Fig. 7.12** that Russia with a percentage share of 22.8 is the leading producer of natural gas, followed by U.S.A. (20.7 %), Canada (7.1%), U.K. (3.9%) and Algeria (3.1%). So far as the consumption of natural gas is concerned USA with a percentage share of 24.4 is the leading consumer, followed by Russia (16 %) , U.K.(3.6 %), Germany(3.5 %) and Canada(3.3%).

The regional distribution of natural gas in U.S.A., Europe, and Australia have been shown in **Figs.7.13, 7.14** and **7.15,** respectively. In USA, the major natural gas deposits lie in Arkansas, California, Colorado, Houston, Indiana, Kansas, Louisiana, Montana, Ohio, Oklahoma, Pennsylvania, Texas, and West Virginia. In Europe, North Sea, Italy, Germany, France, Poland, Romania, and Ukraine have rich deposits of natural gas. The distribution of important mineral resources of Australia including natural gas and petroleum have been shown in **Fig.7.15**. It may be observed from this figure that Australia, a country with small population, is quite endowed with coal, iron-ore, copper, gold, silver, lead, uranium, platinum, tin, and zinc. Australia is one of the important exporters of the basic minerals and energy resources.

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Table 7.7: Leading Natural Gas Producers in the World

Country	Percentage of total production
1. Russia	22.8
2. United States	20.7
3. Canada	7.1
4. United Kingdom	3.9

Table: 7.8: Leading Natural Gas Consumers in the World

Country	Percentage of total consumption
1. United States	24.4
2. Russia	16.0
3. United Kingdom	3.6
4. Germany	3.5
5. Canada	3.3

Table 7.9: Natural Gas Producing Centres

Country	Mining Centres
Algeria	Hassi R'Mel
Australia	Barrow Island, Bass Strait, Flounder, Port Hedland, Scott Reef
Brunei	Bandar Sri Bagawan
Canada	Alberta, British Columbia, Clarke Lake, Edmonton, Saskatchewan
China	Nan-Chang, Sichuan
India	Bombay High, Mangla, Rawa, Tripura
Iraq	Basra, Kirkuk, Mosul
Iran	Agha-Jari, Gach-Saran, Abadan
Indonesia	Palembang, Kalimantan
Libya	Sirte Basin
Mexico	Baja Peninsula, Cardenas, Cludad Madero, Poza Rica Reynosa, Sabinas
Nigeria	Niger Delta
Netherlands	North Sea, Rhine Delta
Romania	Danube Delta
Russia	Grozny, Volga-Ural region, Shaim, Sakhalin
Saudi Arabia	Burgan, Dahran, Dammam, Ghawar, Jubail
U.K.	North Sea
U.S.A.	Albama,Arkansas, California, Colorado, Houston, Indiana, Kansas, Lousiana, Montana, Ohio, Prudhoe Bay (Alaska), Texas, West Virginia Wyoming
Venezuela	Aruba, Maracaibo Lake

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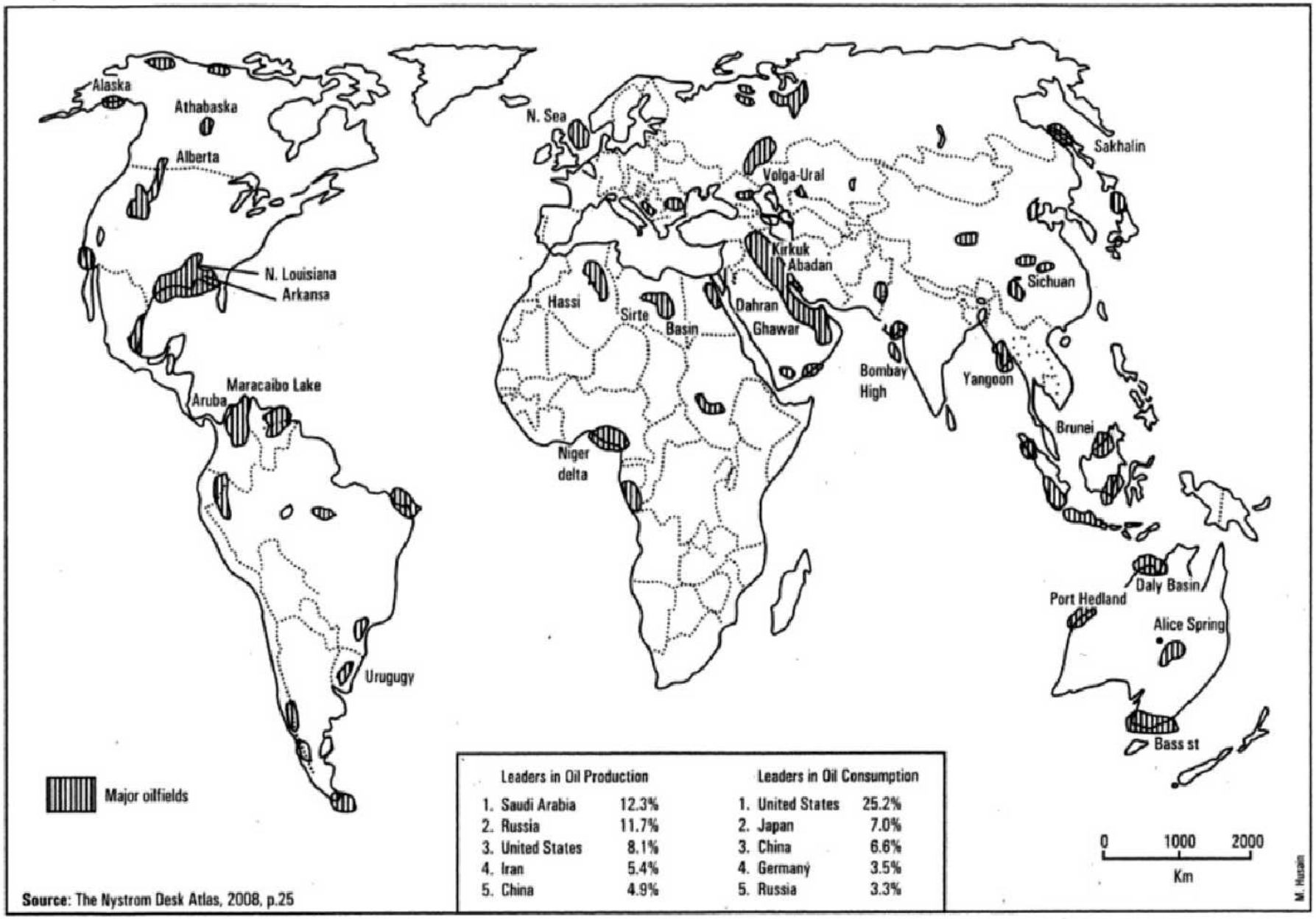

Leaders in Oil Production		Leaders in Oil Consumption	
1. Saudi Arabia	12.3%	1. United States	25.2%
2. Russia	11.7%	2. Japan	7.0%
3. United States	8.1%	3. China	6.6%
4. Iran	5.4%	4. Germany	3.5%
5. China	4.9%	5. Russia	3.3%

Source: The Nystrom Desk Atlas, 2008, p.25

Fig. 7.5 – World – Major oilfields

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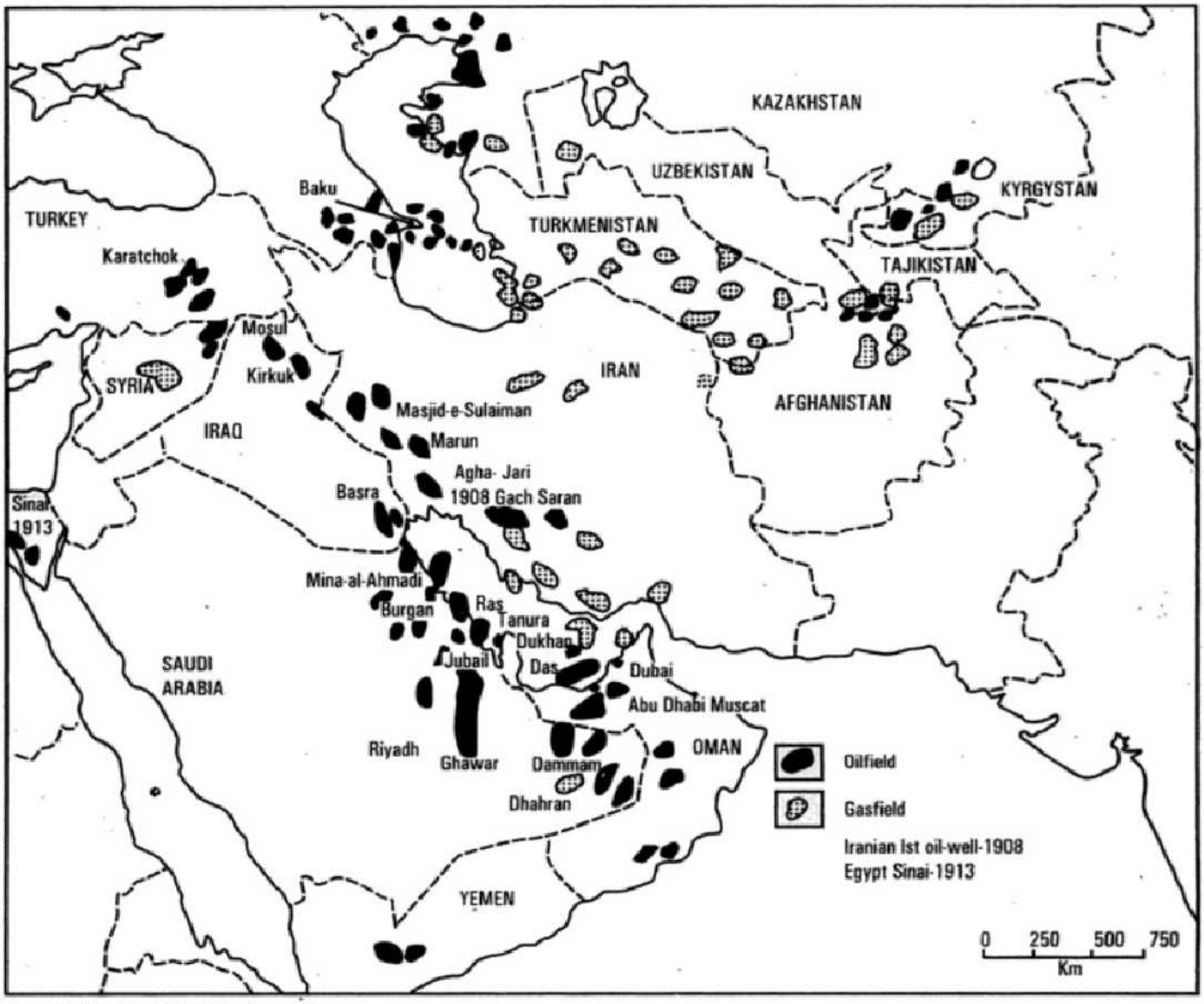

Source: After H.J. de Blij. 9th ed. p. 297

Fig. 7.6 – South West Asia and Central Asia – Oil and natural gas deposits

Mineral Resources

In the economic and industrial development of nations, the importance of minerals can not be under-emphasised. Iron-ore, bauxite and copper are the mainstay of metal production and heavy industries in the world.

Iron Ore

There are several grades of iron ore, based on purity and mineral content. Hematite, the highest grade ore, is reddish in colour. The intermediate grade, magnetite, is characteristically black.

Taconite, the lowest quality ore, requires crushing, magnetic separation, and heating to convert the ore to pellets that are marketable. The distribution and production of iron-ore are highly uneven.

The leading producers and important mining centers of iron-ore have been shown in **Fig. 7.16**.

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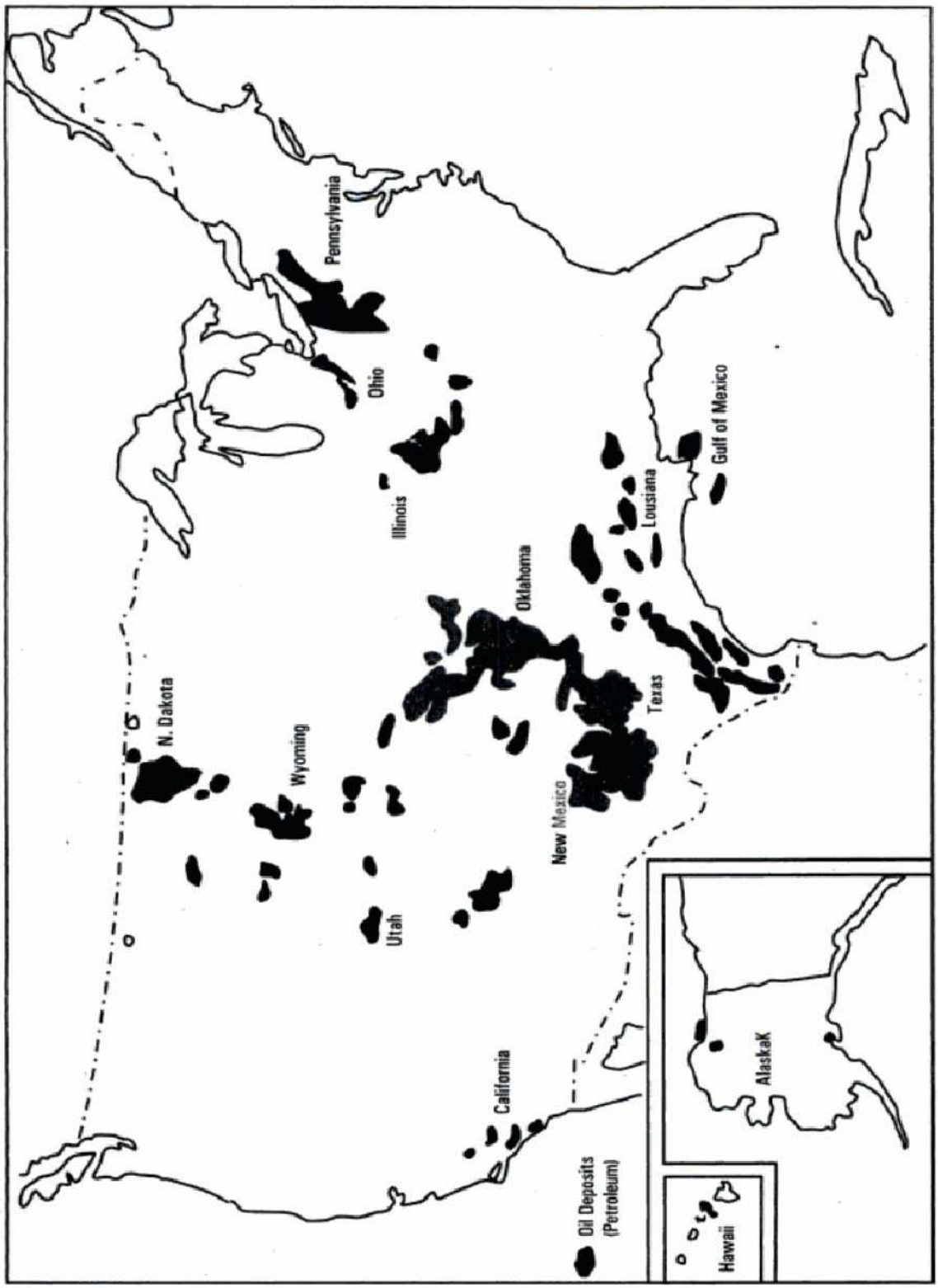

Fig. 7.7 – U.S.A. oil deposits

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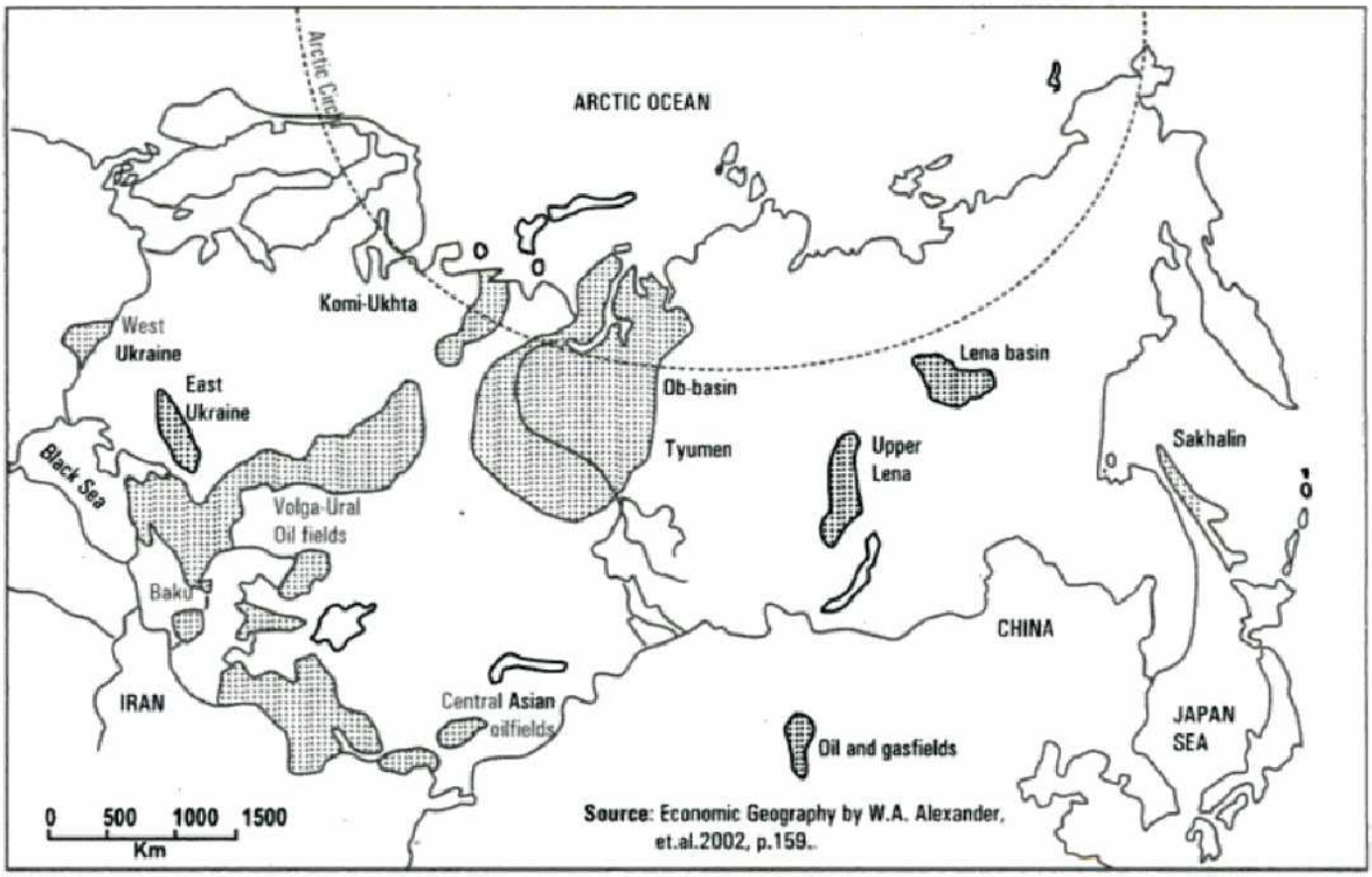

Fig. 7.8 – Russia and Central Asia – Oil deposits

***Table 7.10** : Iron Ore (Fe) – Leading Producers in the World*

Country	*Percentage of total production*
1. China	32.5
2. Brazil	17.7
3. Australia	15.2
4. India	9.6
5. Russia	5.8
6. Ukraine	4.10
7. U.S.A.	2.9
8. South Africa	2.3
9. Canada	1.9
10.Others	8.0

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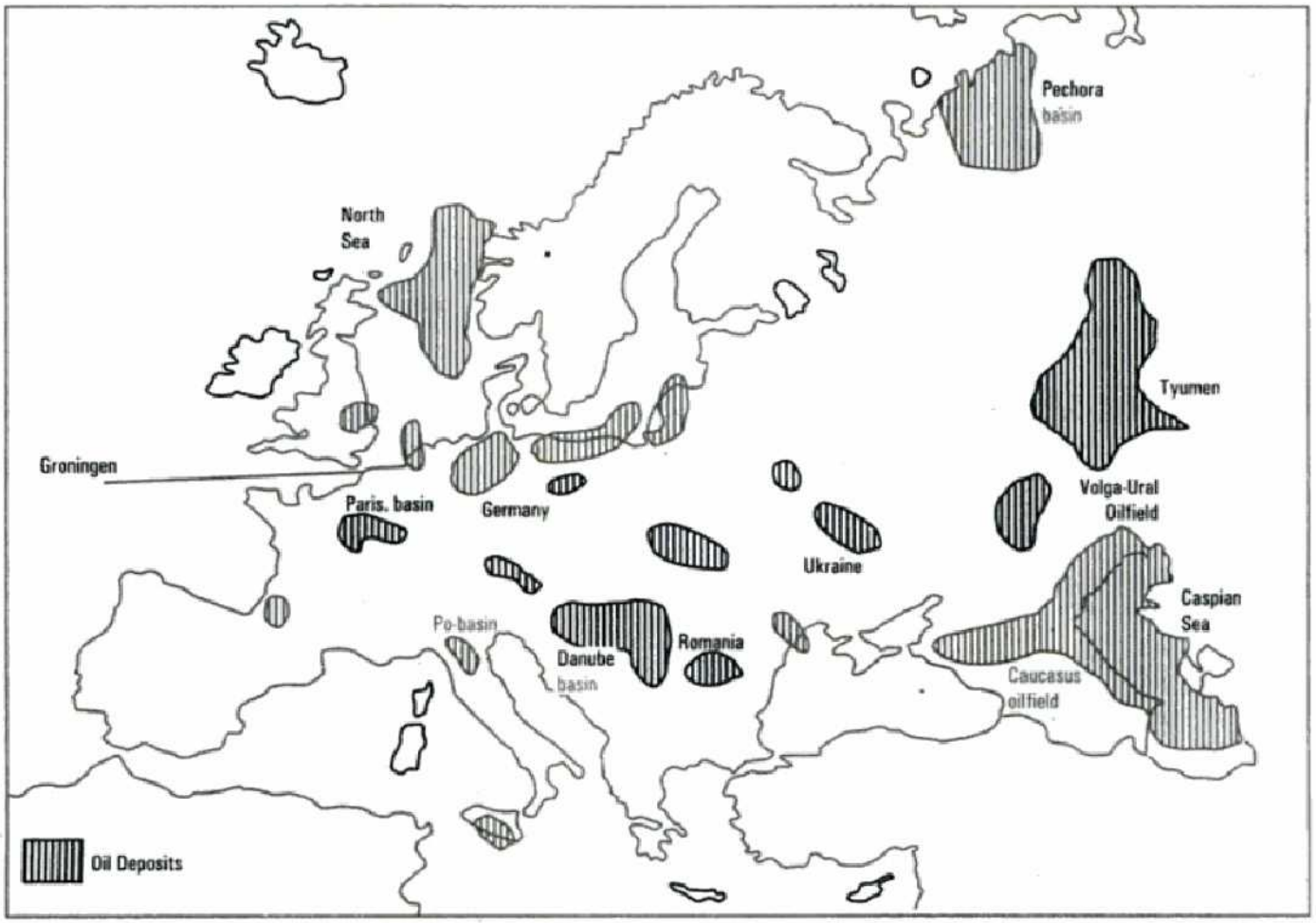

Fig. 7.9 – Europe oil–deposits

***Table 7.11:** Major Iron-Ore Mining Centres of the World*

Country	*Mining Centres*
Brazil	Itabira
Australia	Mt. Bruce, Mt Goldsworthy, Mt Tom Price, Mt. Whaleback
China	Anshan (Manchuria), Chongquing (Chungking), Shandong (Shantung), Sinkiang, Xi-Jiang (Si Kiang), Guangzhou (Canton)
India	Badampahar, Dalli Rajhara, Goa, Kundermukh, Mayurbhanj
Russia	Magnitogorsk(Urals), Kuzbas, Angara (eastern Siberia)
USA	Mesabi Range, Vermilion, Marquette Range (Lake Superior), Adirondacks (New York), Cornwall (Pennsyvania), Albama, Birmingham (Appalachian), California, Utah, Wyoming
Canada	Labrador, Eastern Quebec

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France	Lorraine, Normandy, Central Massif
Germany	Rhur Basin
Liberia	Bomi Hill, Mt. Nimba
Sweden	Kiruna, Gallivare
Ukraine	Krivoi Rog
Mauritania	Zouerate
Chile	Algarrobo in central Chile
Venezuela	Cerro Bolivar (Guiana Highlands)

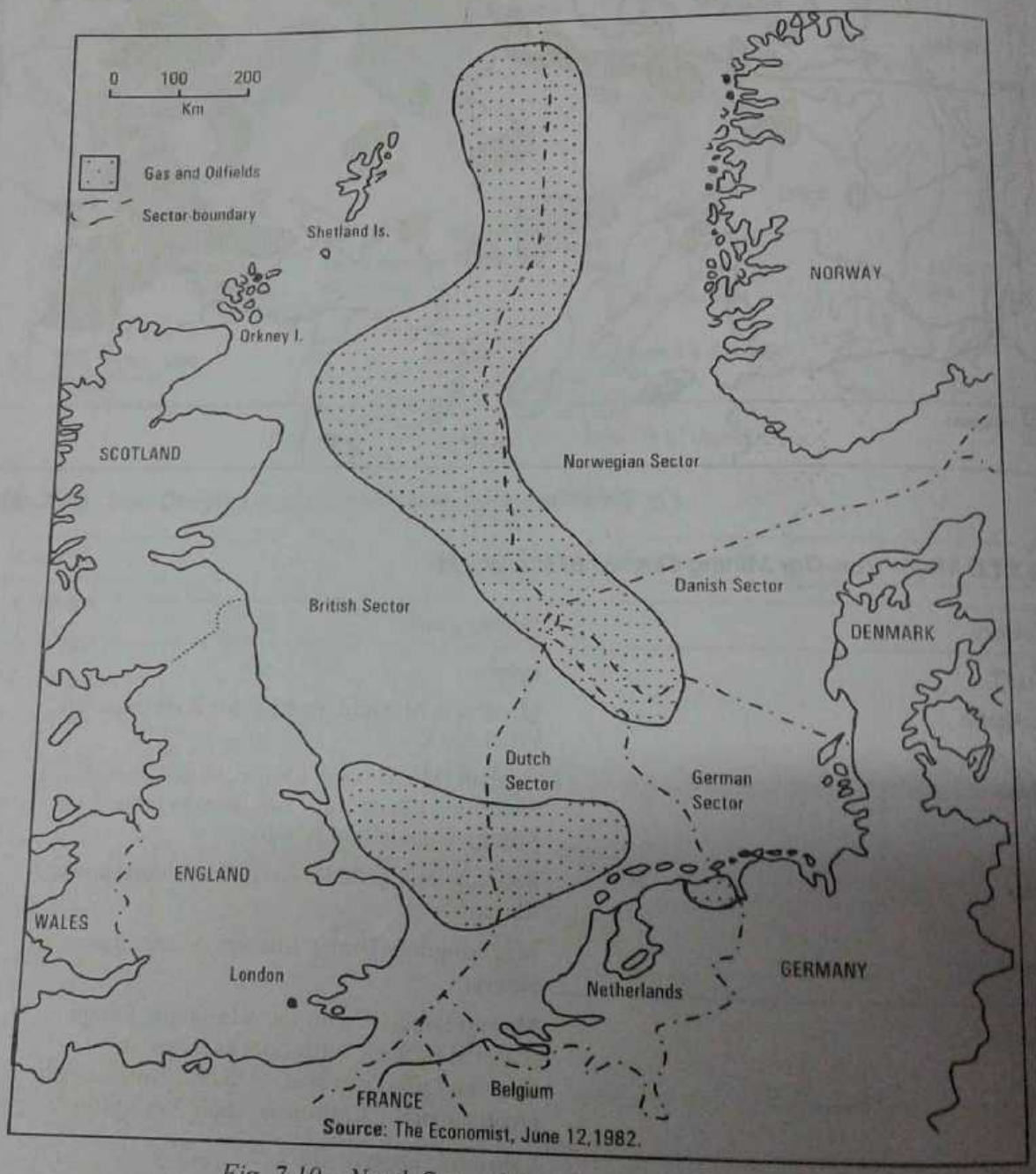
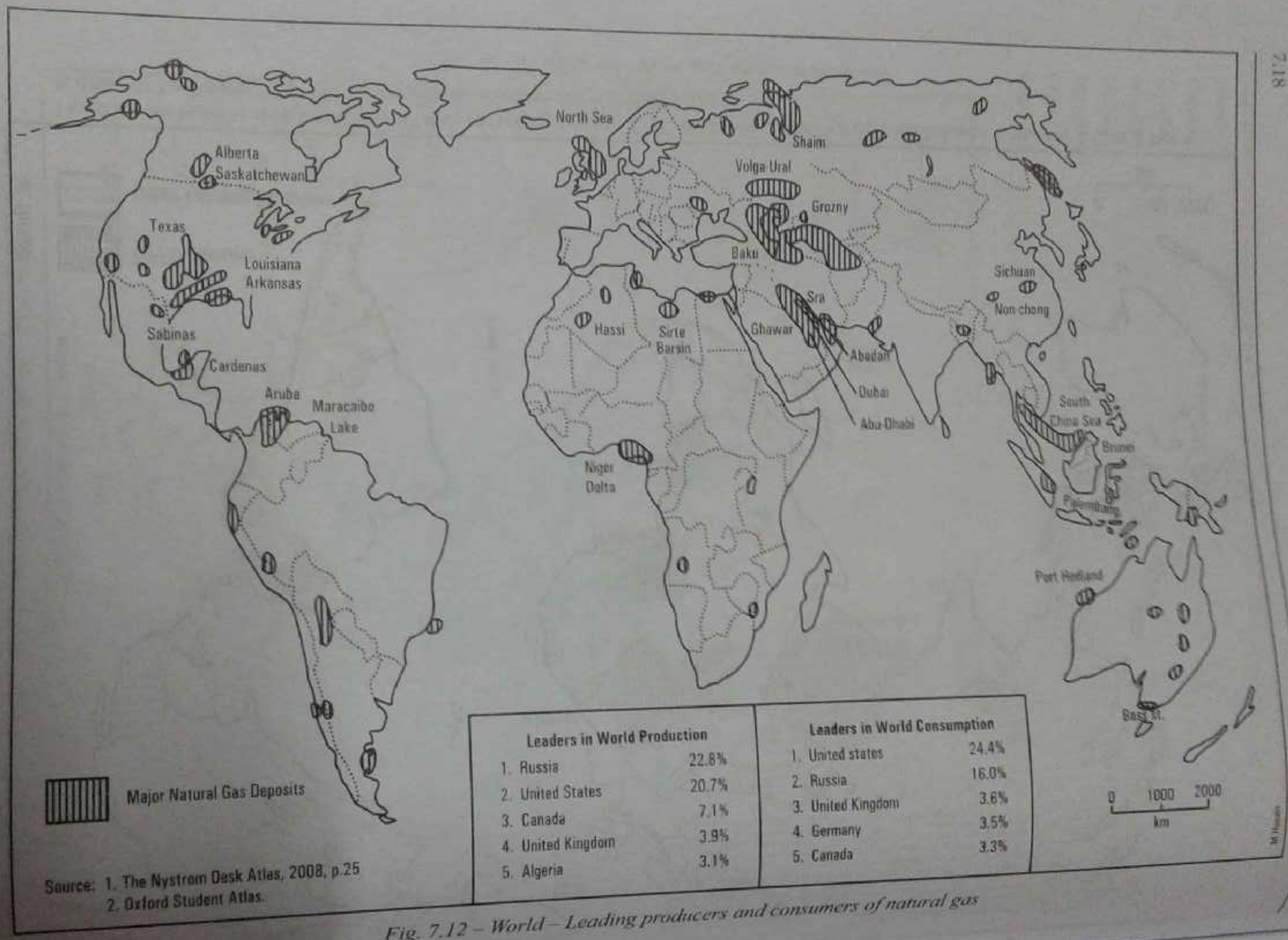


Fig. 7.10 – North Sea – Oil and natural gas deposits

The 12 member countries of the Organisation of Petroleum Exporting Countries (OPEC) are: Angola 2. Algeria 3. Iran, 4. Iraq, 5. Kuwait, 6. Indonesia, 7. Libya, 8. Nigeria, 9. Qatar, 10. Saudi Arabia, 11. U.A.E., 12. Venezuela. (They produce over 40% of the worlds oil.)

Fig. 7.11 – Leading oil exporting countries of the world



Leaders in World Production	
1. Russia	22.8%
2. United States	20.7%
3. Canada	7.1%
4. United Kingdom	3.9%
5. Algeria	3.1%

Leaders in World Consumption	
1. United states	24.4%
2. Russia	16.0%
3. United Kingdom	3.6%
4. Germany	3.5%
5. Canada	3.3%

Source: 1. The Nystrom Desk Atlas, 2008, p.25
2. Oxford Student Atlas.

Fig. 7.12 – World – Leading producers and consumers of natural gas

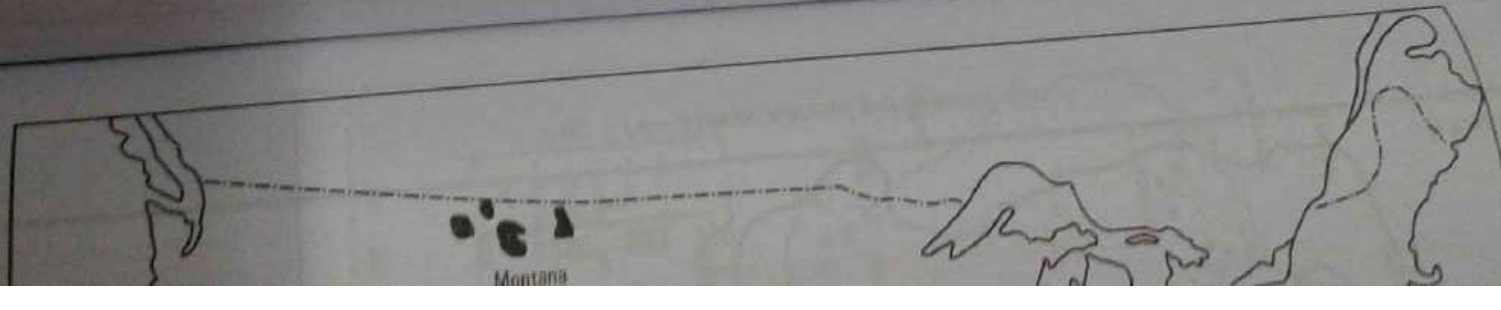


Fig. 7.12 – World – Leading producers and consumers of natural gas

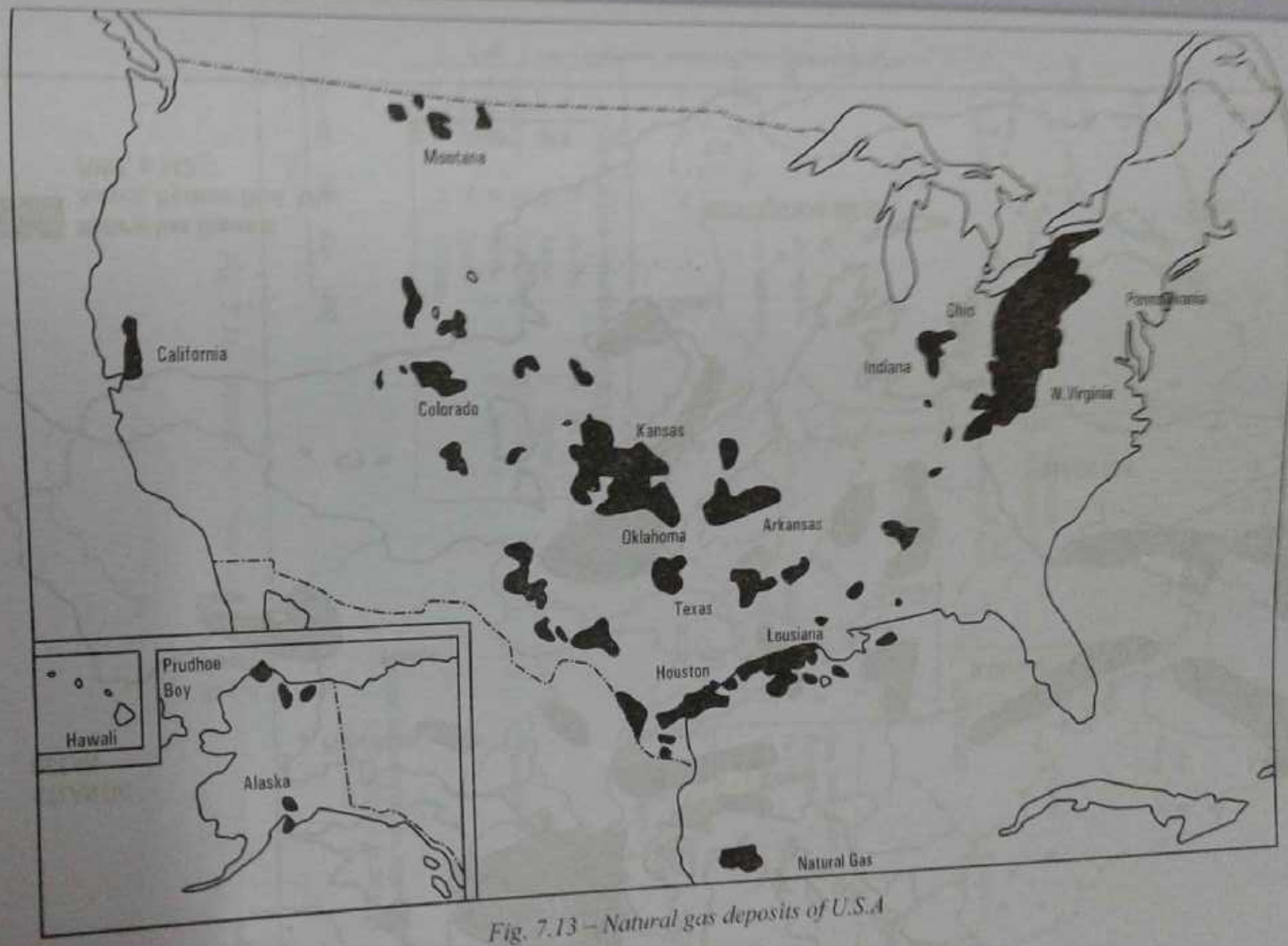


Fig. 7.13 – Natural gas deposits of U.S.A

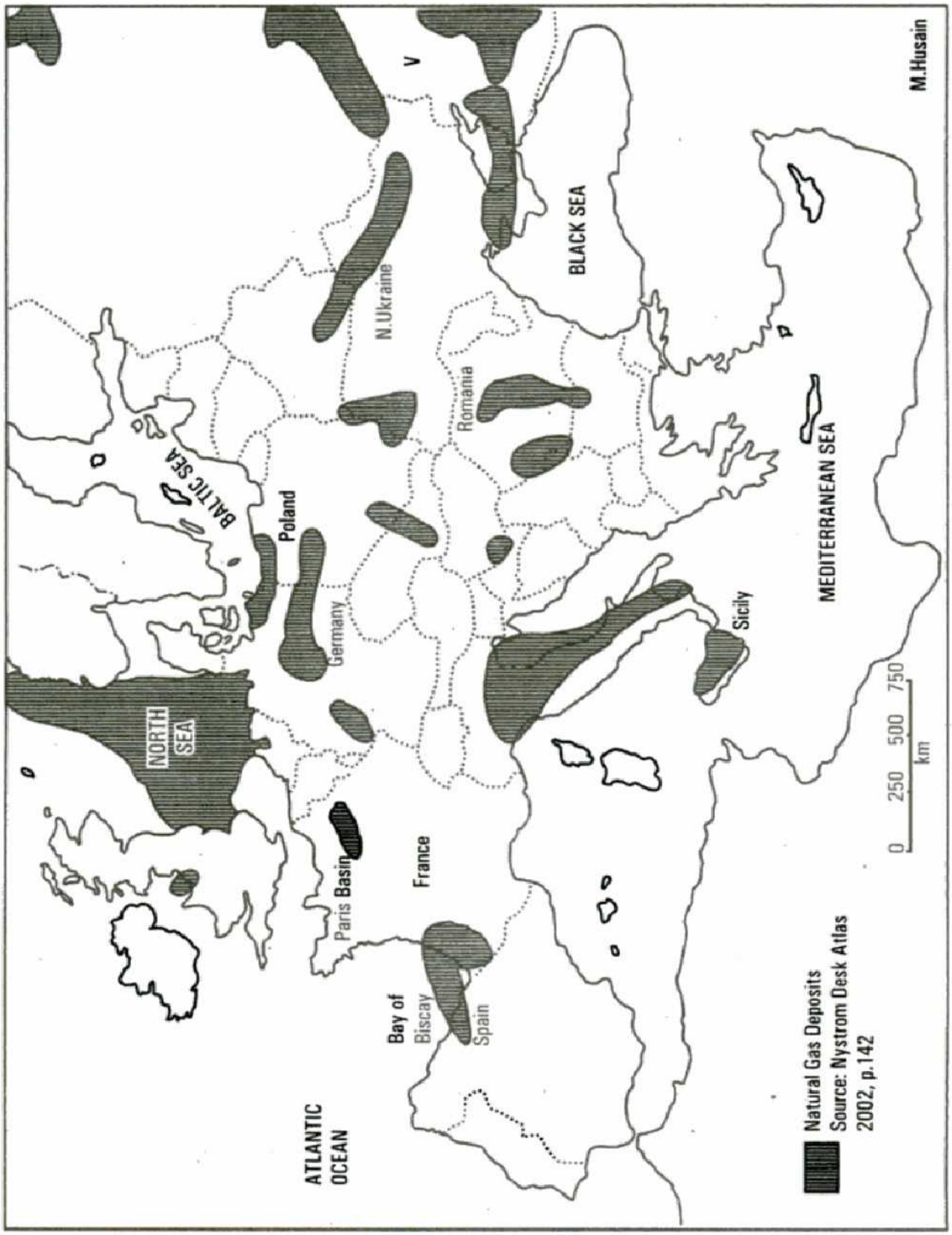


Fig. 7.14 – Europe natural gas deposits

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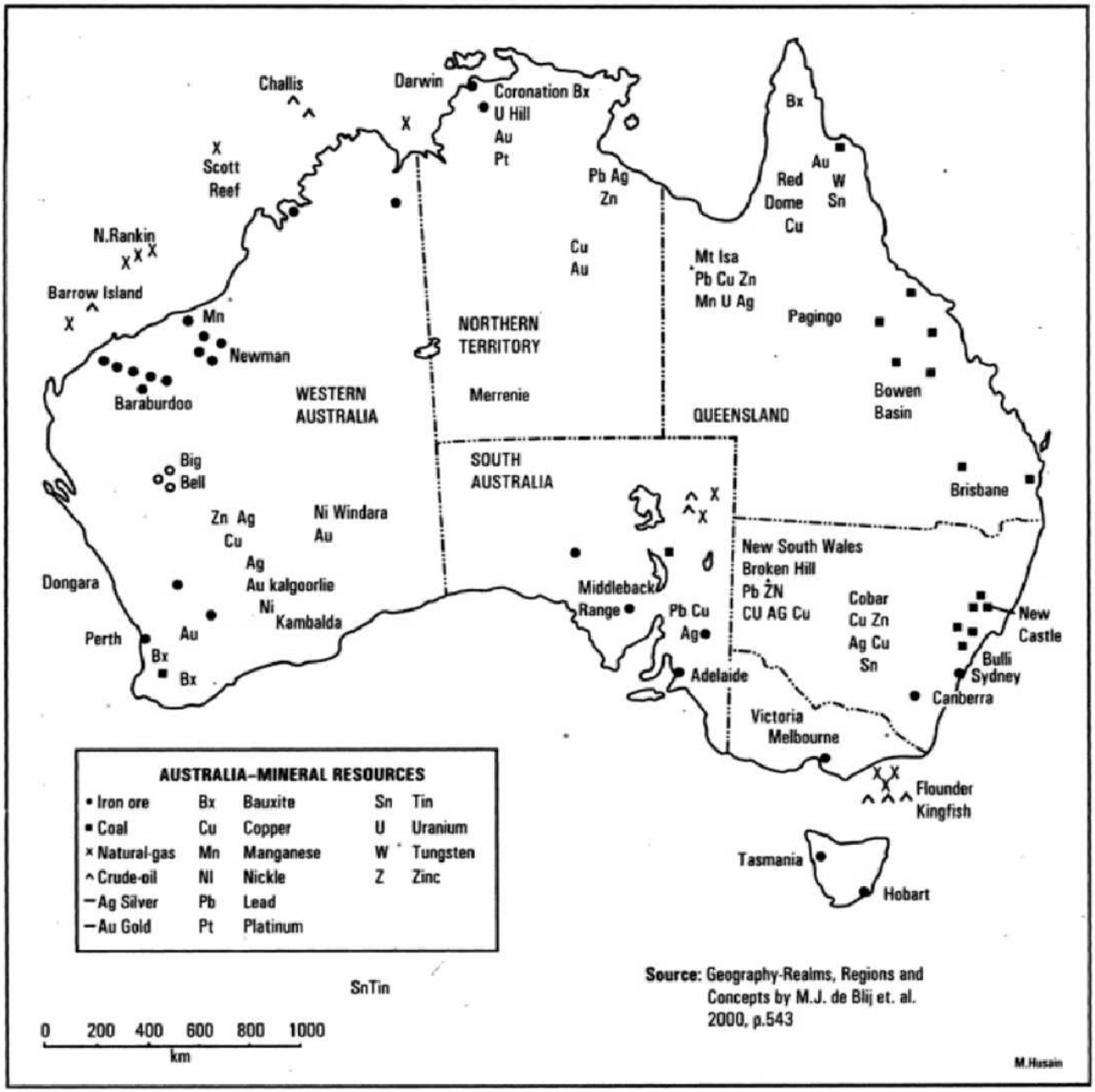

Fig. 7.15 – Australia – Natural gas and mineral resources

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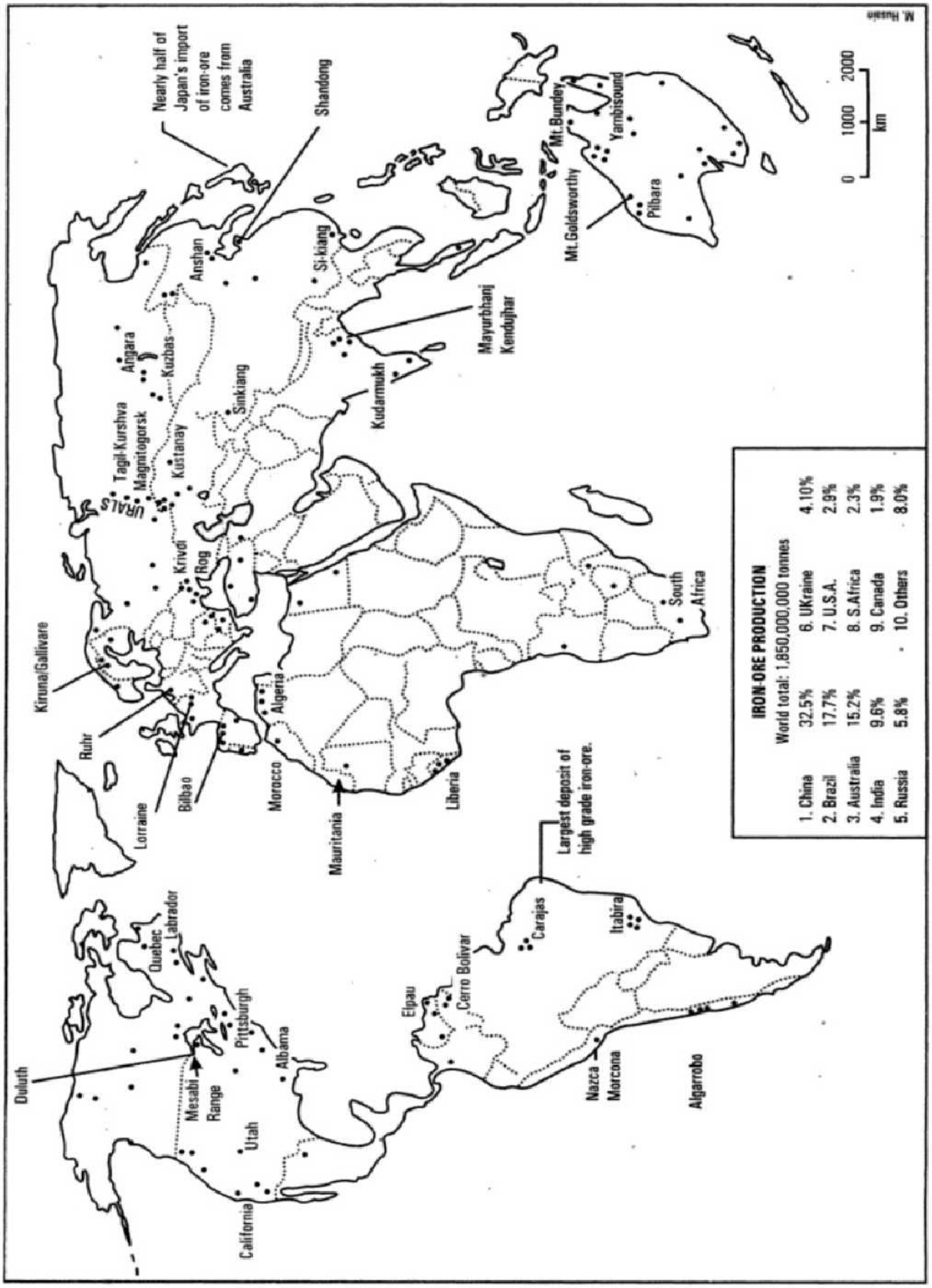

Fig. 7.16 – World major iron ore deposits

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Manganese (Mn)

Manganese is found as a free element or in combination with iron-ore or some other minerals. Manganese compounds were used by the Egyptian and Roman glass makers. It forms only about 0.1% of the Earth's crust. It is an important metal alloy particularly in stainless steel. In fact, it is essential to iron and steel production. It is also used in the manufacturing of disposable batteries. Nearly 80 per cent of the total manganese deposits are found in South Africa. At present, manganese is mainly mined in South Africa, Australia, China, Brazil, Gabon, Ukraine, India and Ghana **(Fig. 7.17)**.

Table 7.12: Manganese: Leading Producers in the World

	Country	Percentage of total production
1.	South Africa	30%
2.	Australia	25%
3.	China	18%
4.	Brazil	10%
5.	Gabon	6%
6.	Ukraine	5%
7.	India	4%

Table 7.13: Table Manganese Deposits (Fig.7.17)

	Country	Manganese Deposits
1.	Australia	Kimberley Plateau
2.	Brazil	Amapa
3.	Chile	Central Chile
4.	China	Hunan, Guiz Hou
5.	Ghana	Nsuta
6.	India	Balaghat, Singhbhum, Goa, Vishakhapatnam
7.	Japan	Honshu
8.	Morocco	Bou Azzer, Imini
9.	Pakistan	Quetta
10.	Philippines	Zambales
11.	Russia	Outokumpu, Urals
12.	South Africa	Postmasburg, Krugersdorp, Rustemburg
13.	Spain	Betican Cordilleras
14.	Turkey	Anatolia Plateau
15.	Ukraine	Chiatura, Nikopol,
16.	U.S.A.	Cuyuna, Nye Butte, Kelloga Butte
17.	Venezuela	Nadola
18.	Zambia	Katanga, Nadola

Fig. 7.16 – World major iron ore deposits

Fig. 7.17 – World – Manganese deposits

Copper(Cu)

The people of Turkey started the use of copper during the pre historic period. It is used for making electric wires, cooking utensils and military products. The ratio of weight loss in copper refining is extremely small, scarcely one per cent of the weight of the refiner's raw material. The main producers of copper in the world have been shown in **Fig. 7.18**. Chile, USA and Indonesia are the leading producers of copper followed by Australia and Peru, Zambia, Zaire border (Zaire's Katanga District). Africa yields about 20 per cent of the total copper production of the world. United States, West Germany, France, Italy, Great Britain and United Kingdom are the main importers of copper, while Chile, Zambia, Belgium/ Luxembourg and Zaire are the main exporters in the world.

***Table 7.14:** Copper–Leading Producers in the World*

Country	*Percentage of total production*
1. Chile	34.8
2. United States	8.8
3. Indonesia	7.9
4. Australia	6.3
5. Peru	5.9

***Table 7.15:** Main Mining Centres of Copper*

Country	*Mining Centres*
Chile	Braden, Chuquicamata, El-Teniente, Potrerillos
USA	Ajo, Bisbee, Morenci (Arizona), Bingham (Utah), Butte(Montana), New Mexico, Alaska
Indonesia	Sumatra
Australia	Broken Hill, Mt. Isa, Mt. Morgan
Jamaica	Jamaica
Zambia	Nechanga, Kitwe, Mufulira Copper Belt
Zaire	Katanga-Zambia Copper Belt
Russia	Dzhezkazgan, Norilsk, Urals
Japan	Honshu, Shikoku
Peru	Morococha
India	Balaghat, Khetri (Jhunjhunu-Rajasthan)
South Africa	Transvaal
Canada	Flin Flon, Nunavut, Sudbury

Bauxite

Bauxite is the raw material for aluminum industry. Bauxite occurs more frequently in tropical areas having clay-limestone rocks exposed to weathering. Bauxite formation is attributed to lateritic weathering. It is the raw material for aluminium which is an important metal because it combines the strength of such metals as iron, with extreme lightness and also with great conductivity and malleability. The bauxite is first crushed, washed and dried in a

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rotary kiln at a temperature of over 982°C. Its plants are located either close of the hydel-power or near the sea coasts. In 2009, Australia producing about one-third of the world's production became the leading producer of bauxite in the world. Australia is followed by China, Brazil, Jamaica, Guinea, Surinam, Russia, Guyana, USA, France and India.

About 95 per cent of the world's bauxite production is processed first into alumina, and then into aluminum by electrolysis. Its smelting requires cheap hydro-power. Consequently, the leading producers of aluminum in the world are Canada, Norway, USA, Japan, and West Germany.

The leading consumers of aluminum are USA, Japan, Russia, China.

Germany, France and U.K. The leading producers of bauxite are given in **Table 7.16.**

***Table 7.16:** Leading Producers of Bauxite*

	Country	*Percentage of total production*
1.	Australia	34.0
2.	China	14.0
3.	Brazil	12.0
4.	Jamaica	11.0
5.	Guinea	10.0
6.	Surinam	5.5
7.	Russia	3.5
8.	Guyana	2.5
9.	U.S.A.	1.5
10.	France	0.5

Tin: The leading tin producing countries and the important mining centres have been shown in **fig. 7.19** and also given in tables **7.17** and **7.18** respectively.

***Table 7.16:** World: Leading Producers of Tin*

	Country	*Percentage of total production*
1.	China	35.9
2.	Indonesia	29.6
3.	Peru	15.8
4.	Bolivia	6.4
5.	Brazil	4.8

***Table 7.17:** Main Tin Mining Centres*

Country	*Mining Centres*
Australia	Mt. Isa (Queensland)
Bolivia	Potosi (Andes)
Brazil	Grossa, Mato, Rondonia
China	Hubei, He Xian (Honsein), Jiangsa, Nanling Shan
Indonesia	Banka Billiton and Singkep (Sumatra)

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Malaysia	Kinta Valley (around Kuala Lumpur), Larut Plain, Kelang Valley, Jelebu Valley, Kota Tinggi
Nigeria	Bauchi Plateau
Thailand	Kara Peninsula, Phuket Island, Ranong, Phangnga, Takuapa
UK	Cornwall
Zaire	Katanga Plateau

Gold (Au)

Gold is a valuable and the most sought precious metal. Gold is the most malleable and ductile of all metals; a single gram can be beaten into a sheet of one square meter. About 50 per cent of the gold is used for jewellery, 40 per cent in investment, and 10 per cent in industry. Today, the international monetary system is backed by gold. The distribution and major producers of gold have been given in **Fig. 7.20.**

In 2009, South Africa was the leading producer of gold, followed by China. The other major producers are United States, Australia, Russia, Peru, Chile and Argentina. The *Savuka* mines of South Africa are the deepest gold mines of the world with a depth of 3777 m.

Table 7.19: Leading Producers of Gold in the World

	Country	Percentage to total production
1.	South Africa	14.7
2.	China	11.1
3.	U.S.A.	10.8
4.	Australia	8.1
5.	Russia	6.7
6.	Peru	5.0

Silver (Ag)

Silver is one of the precious metals and is used to make ornaments, jewellery, high value tableware, utensils (*silverware*), decorative items, mirrors, and currency coins. It is also used in medicines, food, optics, photography, construction of high quality musical instruments, flutes, etc. It is found in native form, an alloy with gold, sulfur, arsenic, antimony or chlorine. The leading producers of silver are Peru, Mexico, China, Australia, Chile, Poland and Serbia **(Fig. 7.21)**.

The famous silver producing mines are *Proaño/Fresnillo* (Mexico) *Cannington* (Queensland-Australia), *Dukat* (Russia), *Uchucchacua* (Peru) and *Green Creek Mines* (Alaska).

Table 7.20: Silver – Leading Producers in the World

	Country	Percentage to total production
1.	Peru	15.6
2.	Mexico	14.2
3.	China	12.5
4.	Australia	10.9
5.	Canada	7.2

Fig. 7.18 – World – Copper deposits

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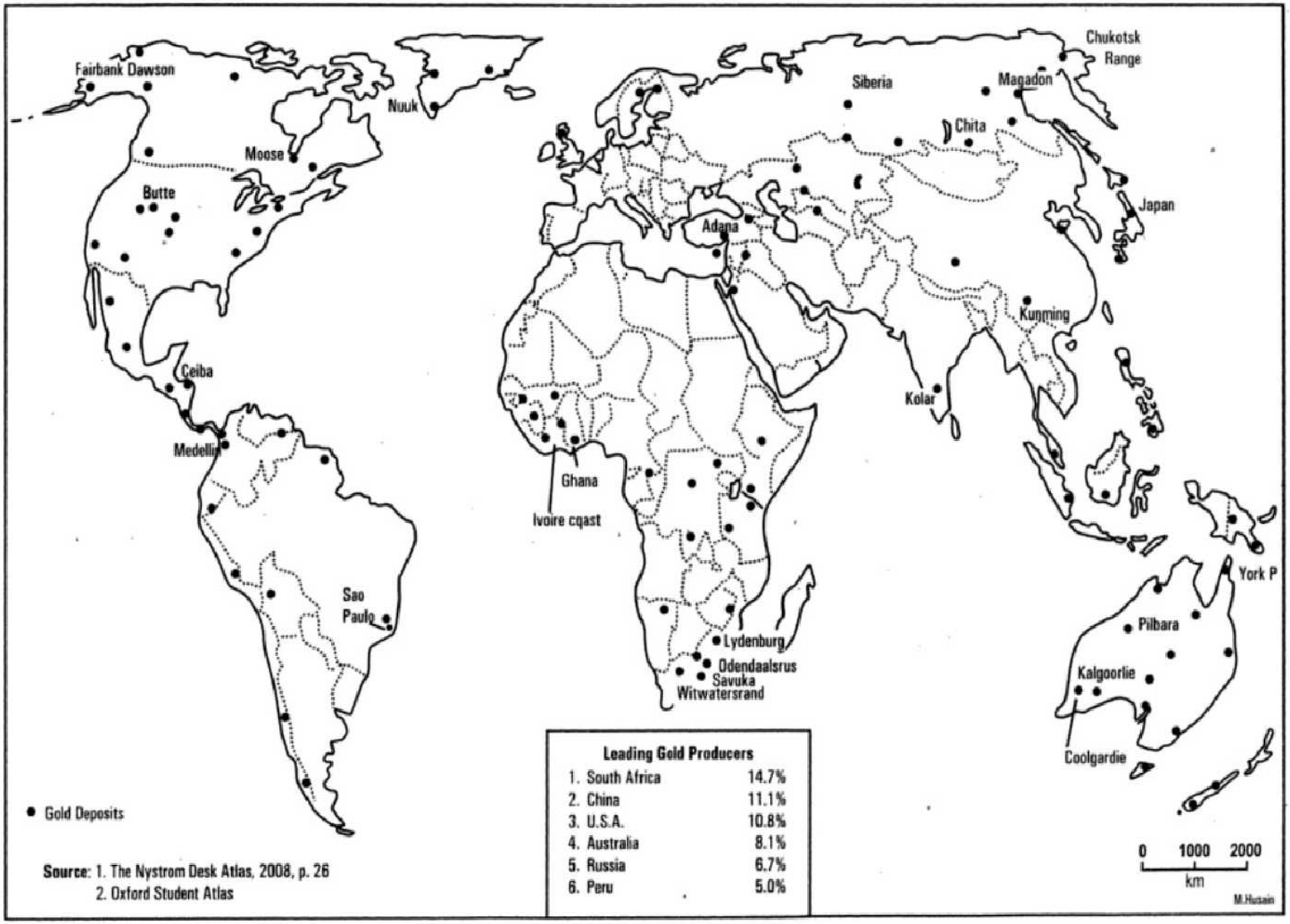
Fig. 7.19 – World – Distribution of tin deposits



Leading Gold Producers

1. South Africa	14.7%
2. China	11.1%
3. U.S.A.	10.8%
4. Australia	8.1%
5. Russia	6.7%
6. Peru	5.0%

Source: 1. The Nystrom Desk Atlas, 2008, p. 26
2. Oxford Student Atlas

Fig. 7.20 – World – Gold deposits

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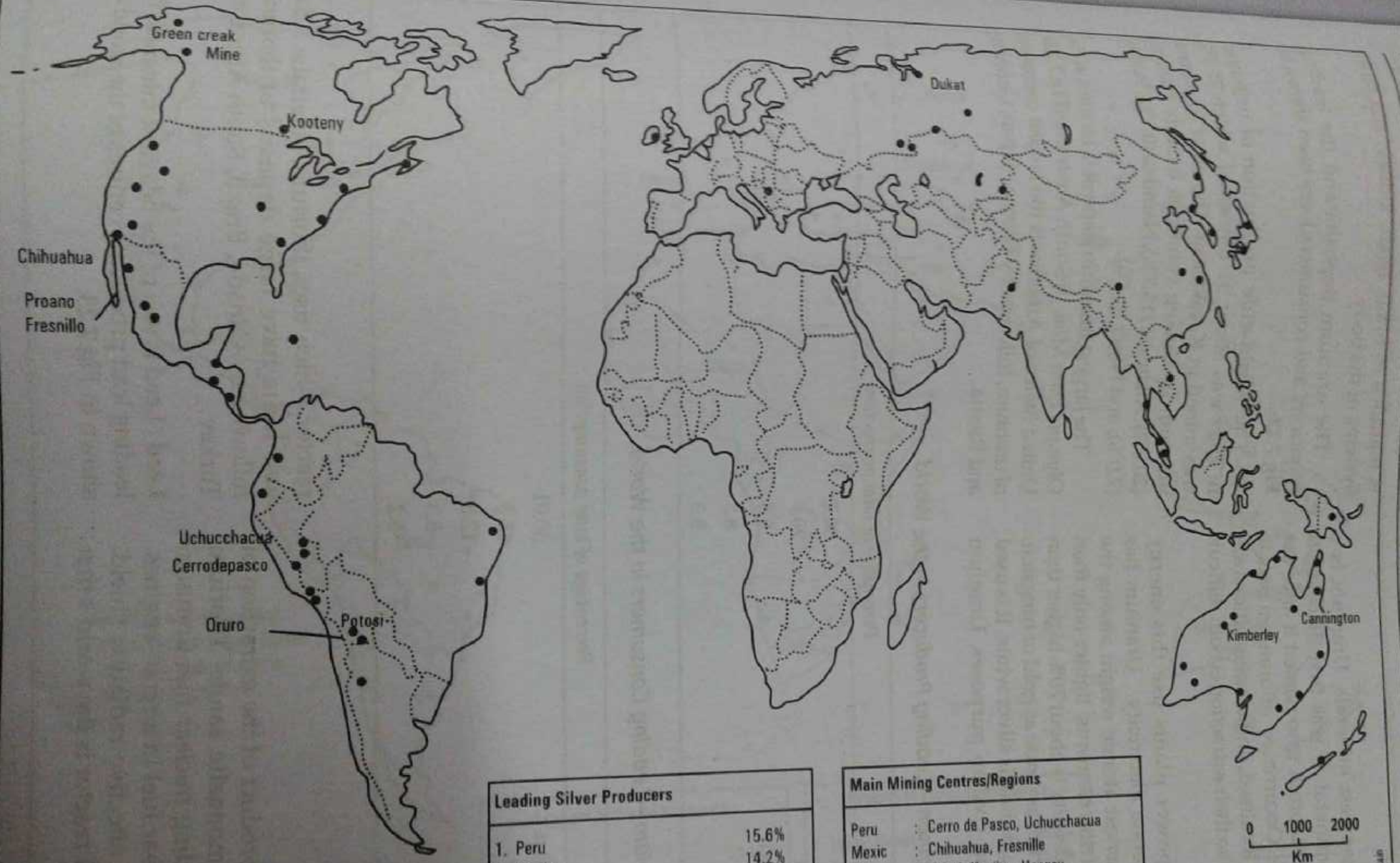

Leading Silver Producers	
1. Peru	15.6%
2. Mexico	14.2%
3. China	12.5%
4. Australia	10.9%
5. Canada	7.2%

Main Mining Centres/Regions	
Peru	: Cerro de Pasco, Uchucchacua
Mexic	: Chihuahua, Fresnille
China	: Anhui, Nanjing, Hangsu
Australia	: Kimberley, Cannington
Canada	: Kooteny, Arnhemland

Source: The Nystrom Desk Atlas, 2008, p. 26

Fig. 7.21 – World – Silver deposits

Uranium (U)

One of the heaviest minerals, Uranium is a radio-active mineral. It was first discovered by Martin H. Klaproth who named it after the planet Uranus. Occurrence of uranium ores is very rare and localised, and concentrations are generally low, so their extraction is both difficult and costly.

Nuclear power plants use this energy source to generate electricity. Uranium has the second heaviest atomic weight among the naturally occurring elements, lighter only than plutonium. Its density is about 70% higher than that of lead, but not as dense as gold or tungsten. When refined, uranium is silver white. It is used for military and civilian purposes. Uranium is injurious to brain, heart, kidney, and other systems of the body.

The uranium deposits and the leading producers and consumers have been shown in **Fig.7.22**.

The worldwide production of uranium in 2009 was about 51 tonnes of which 27.3% was mined in Kazakhstan. The other important uranium producing countries include Canada (20.0%), Australia (15.7%), Namibia (0.1%), Russia (7.0%), and Niger (6.4%).

The largest uranium deposit is located at the *Olympic Dam Mine* in South Australia **(Fig.7.22).** United States of America is the largest consumer of uranium, followed by France, Japan, Germany and Russia.

***Table 7.21:** Uranium – Leading Producers in the World*

	Country	*Percentage of total production*
1.	Canada	30.1
2.	Australia	20.9
3.	Kazakhstan	8.8
4.	Niger	8.5
5.	Russia	8.3

***Table 7.22:** Uranium – Leading Consumers in the World*

	Country	*Percentage of total consumption*
1.	United States	30.01
2.	France	15.5
3.	Japan	12.5
4.	Germany	5.3
5.	Russia	5.2

Thorium (Th)

Thorium is a by-product of the extraction of rare earths from monazite sands. Thorium was used for breeding nuclear fuel-uranium. It is used as a nuclear fuel in aircraft engines. Thorium is a very effective radiation shield. India's Kakrapara-1 reactor is the world's first reactor which uses thorium. Australia, USA, and India have large deposits of thorium, followed by Canada, Brazil, South Africa and Turkey.

Lead : Lead is one of the heaviest minerals. The leading lead producing centres of the world are shown in **Fig.7.23**.

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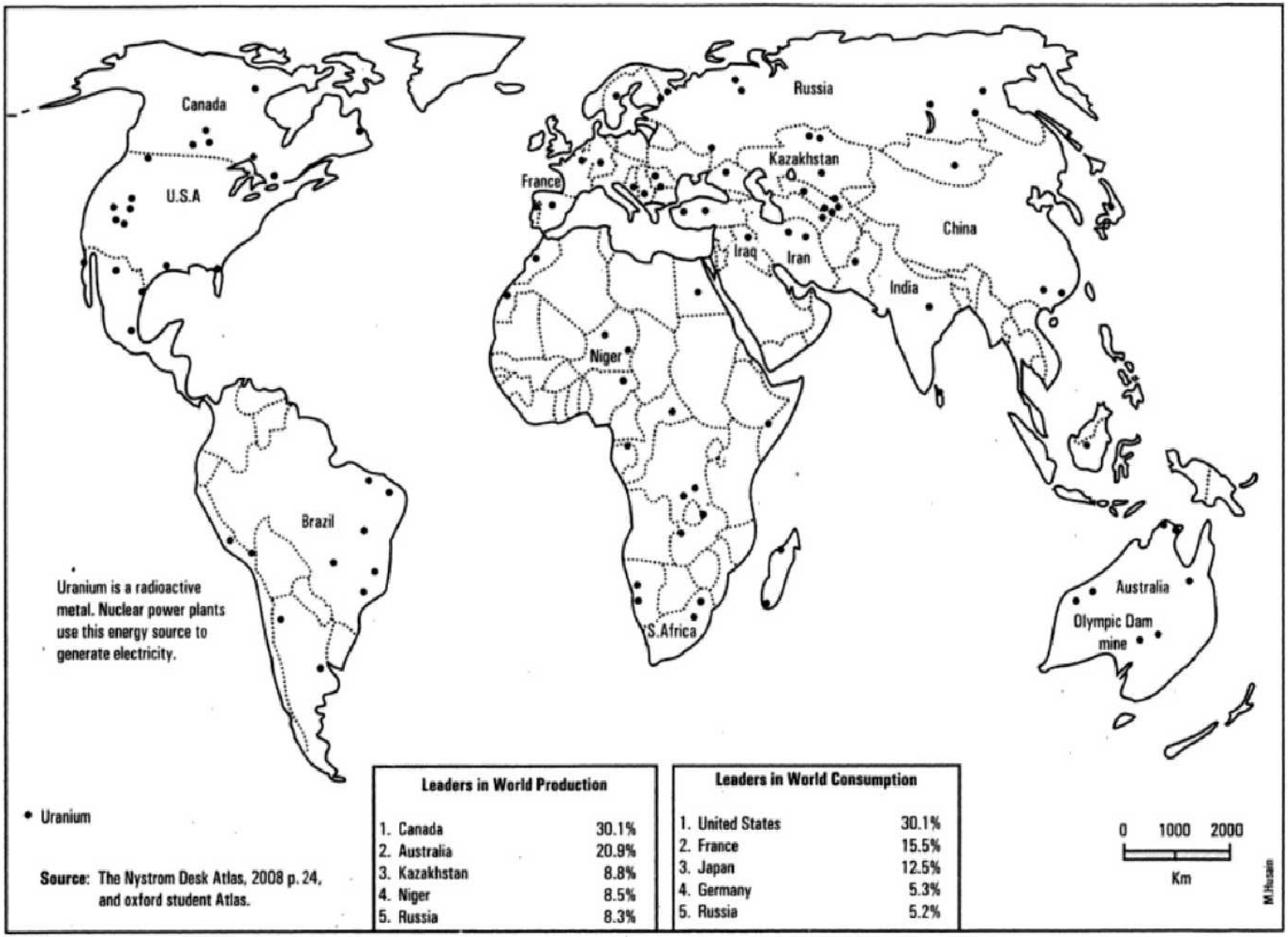

Fig. 7.22 – World uranium deposits

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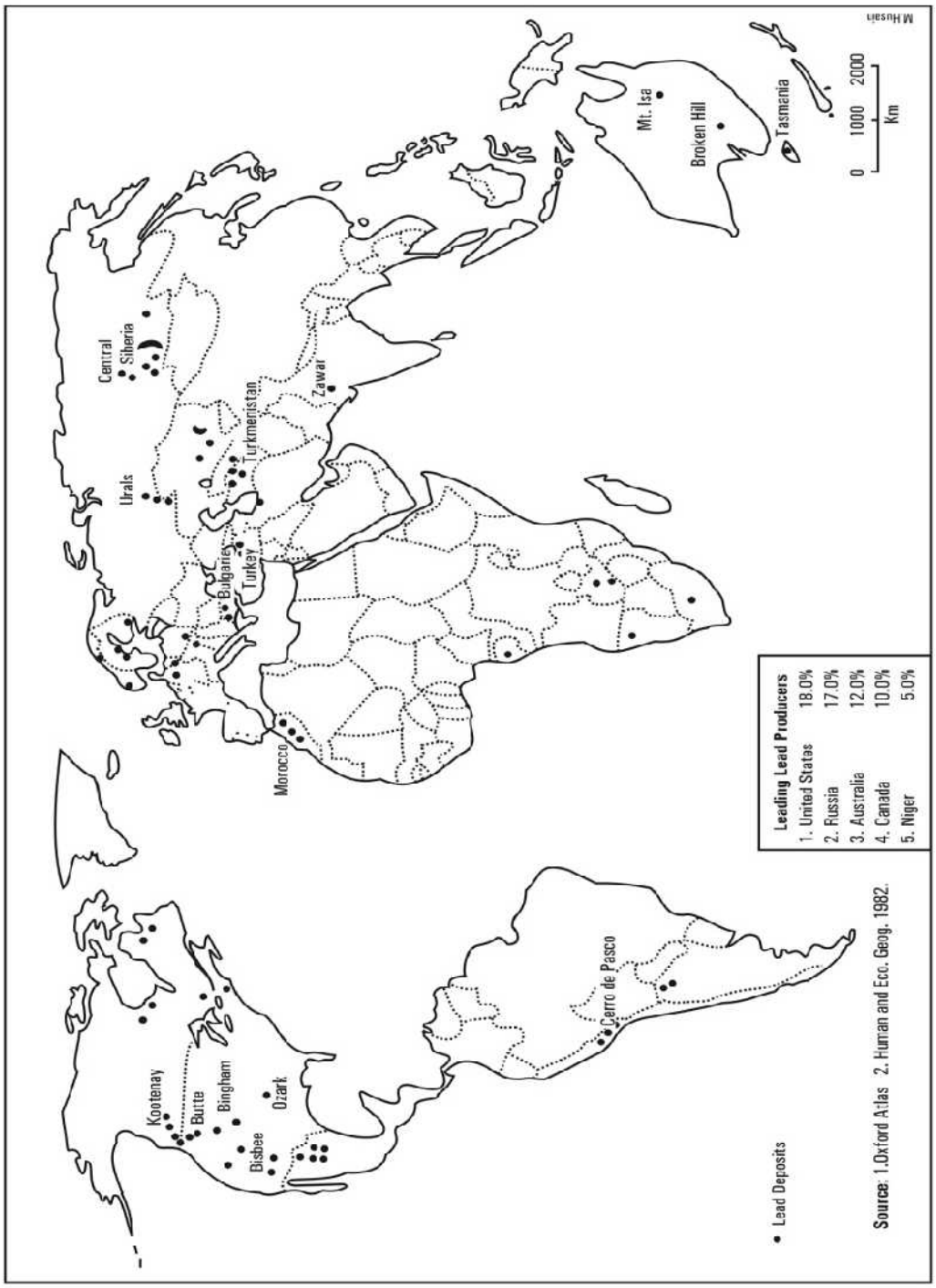

Fig. 7.23 – World – Lead deposits

***Table 7.23:** Leading Producers of Lead in the World*

	Country	*Percentage to total production*
1.	United States	18.0
2.	Russia	17.0
3.	Australia	12.0
4.	Canada	10.0
5.	Niger	5.0

Zinc

The leading zinc producing countries and its main mining centres have been shown in **Fig. 7.24.**

***Table 7.24:** Zinc – Leading Producers in the World*

	Country	*Percentage to total production*
1.	China	21.1
2.	Australia	14.3
3.	Peru	13.7
4.	Canada	9.0
5.	United States	8.3

Nickel: The distribution of nickel and its leading producers have been shown in **Fig. 7.25.**

***Table 7.25:** Nickle–Leading Producers in the World*

	Country/Mining Centres	*Percentage of total production*
1.	Russia (Severo, Siberskaya, Urals)	23.2
2.	Australia (Broken Hill, Mt. Isa, Pilbara)	15.2
3.	Canada (Sudbury, Lynn Lake, Thompson and Hope)	13.3
4.	Indonesia	9.0
5.	New Caledonia (Fr.)	8.0

Industrial Regions

Some of the main industrial regions have been shown in **Figs. 7.26-7.28,** while their main industries have been given in **Table 7.26.**

***Table 7.26:** Main Industrial Regions of the World*

Industrial Region	*Main Industries*
Europe	
Bohema	Iron and steel, heavy machinery, mining equipments, electric goods, light machinery, consumer goods, agricultural machinery **(Fig. 7.26).**

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Lorraine	Iron and steel, textiles, heavy and light machinery, consumer goods, brewery, food processing **(Fig. 7.26).**
Moscow	Iron and steel, cotton and woolen textiles, engineering goods, assorted machinery, automobiles, electric goods, pharmaceutical and food processing **(Fig. 7.26).**
Po-Basin	Automobiles, electronic goods, consumer goods, porcaline, agricultural machinery, financial services **(Fig. 7.26).**
Ruhr Basin	Iron and steel, heavy machinery, petrochemicals, mining equipments, electronic goods, agricultural machinery, consumer items **(Fig. 7.26).**
Saar Basin	Iron and steel, automobiles, electric goods, electronics, chemicals, agricultural machinery, textiles and food processing **(Fig. 7.26).**
Zabrze	Heavy machinery, mining equipments, automobiles, electric goods, electronics, consumer goods, textiles, and food processing.
Cardiff -Swansea (Wales)	Ship-building, iron and steel, heavy machinery, automobiles, petrochemicals, light machinery, consumer goods, food-processing **(Fig. 7.27).**
Glasgow	Ship-building, iron and steel, heavy machinery, automobiles, consumer goods and food processing **(Fig. 7.27).**
Manchester-Liverpool	Ship-building, textiles, light machinery, utensils **(Fig. 7.27).**
New Castle	Ship-building, machinery and consumer goods.
Volga Region	Petrochemical, textiles, electric goods, agricultural machinery
Industrial Cities of Great Lakes (N.A.)	
Buffalo	Iron and steel, electrical appliances, chemicals, grains-milling **(Fig. 7.28).**
Cleveland	Automobiles, Iron and steel, automobiles, petrochemical, engineering goods, precision instruments, consumer goods **(Fig. 7.28).**
Detroit (Motown or Motor-Town)	Automobiles, Headquarters of Ford, General Motors, Chrysler, consumer goods, food processing **(Fig. 7.28).**
Duluth	Grain exporting, fir-trade, electric goods **(Fig. 7.28).**
Gary	Heavy machinery, electric goods, engineering goods, precision instruments, agricultural machinery **(Fig. 7.28).**
Milwaukee	Brewing, chemicals, light machinery, electric goods, food processing **(Fig. 7.28).**
Toledo	Automobiles, iron and steel, glass products, ceramics, fruits-packing, dairy products **(Fig. 7.28).**
Toronto	Iron and steel, air-crafts, chemicals, pharmaceuticals, textiles, agricultural machinery and food processing **(Fig. 7.28).**

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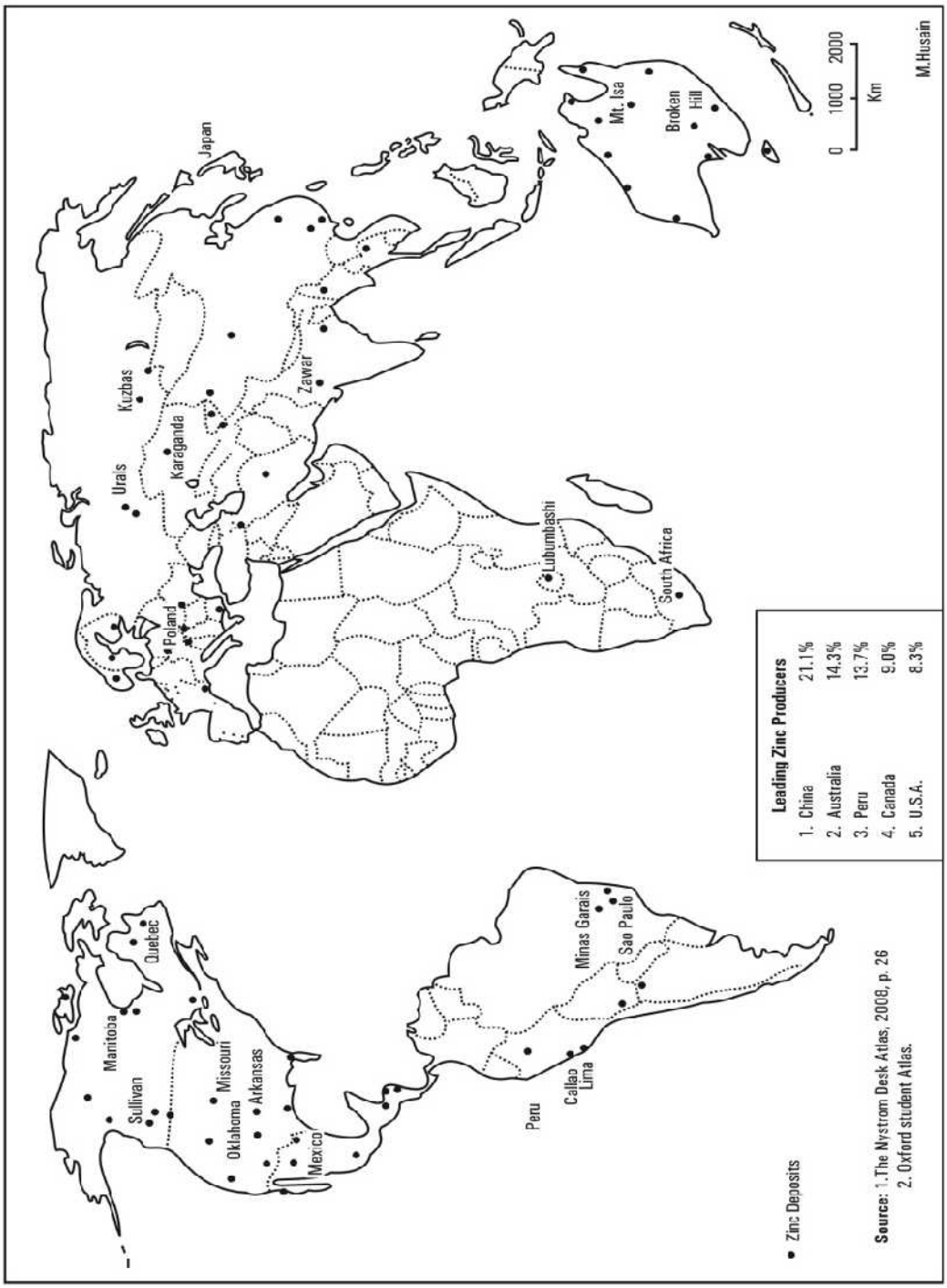

Fig. 7.24 – World zinc deposits

Fig. 7.25 – World – Nickle deposits

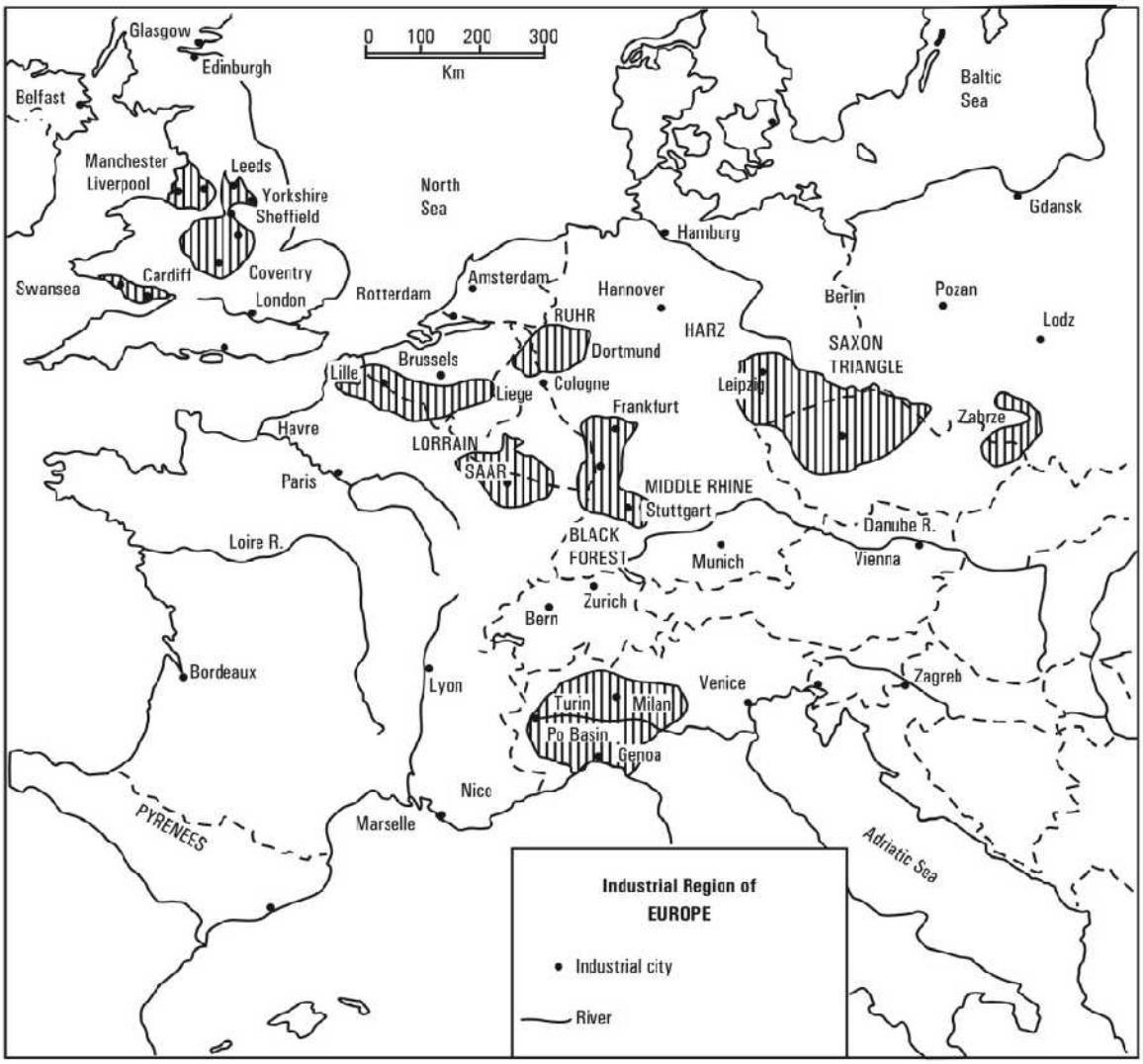

Fig. 7.26 – Industrial regions of Europe

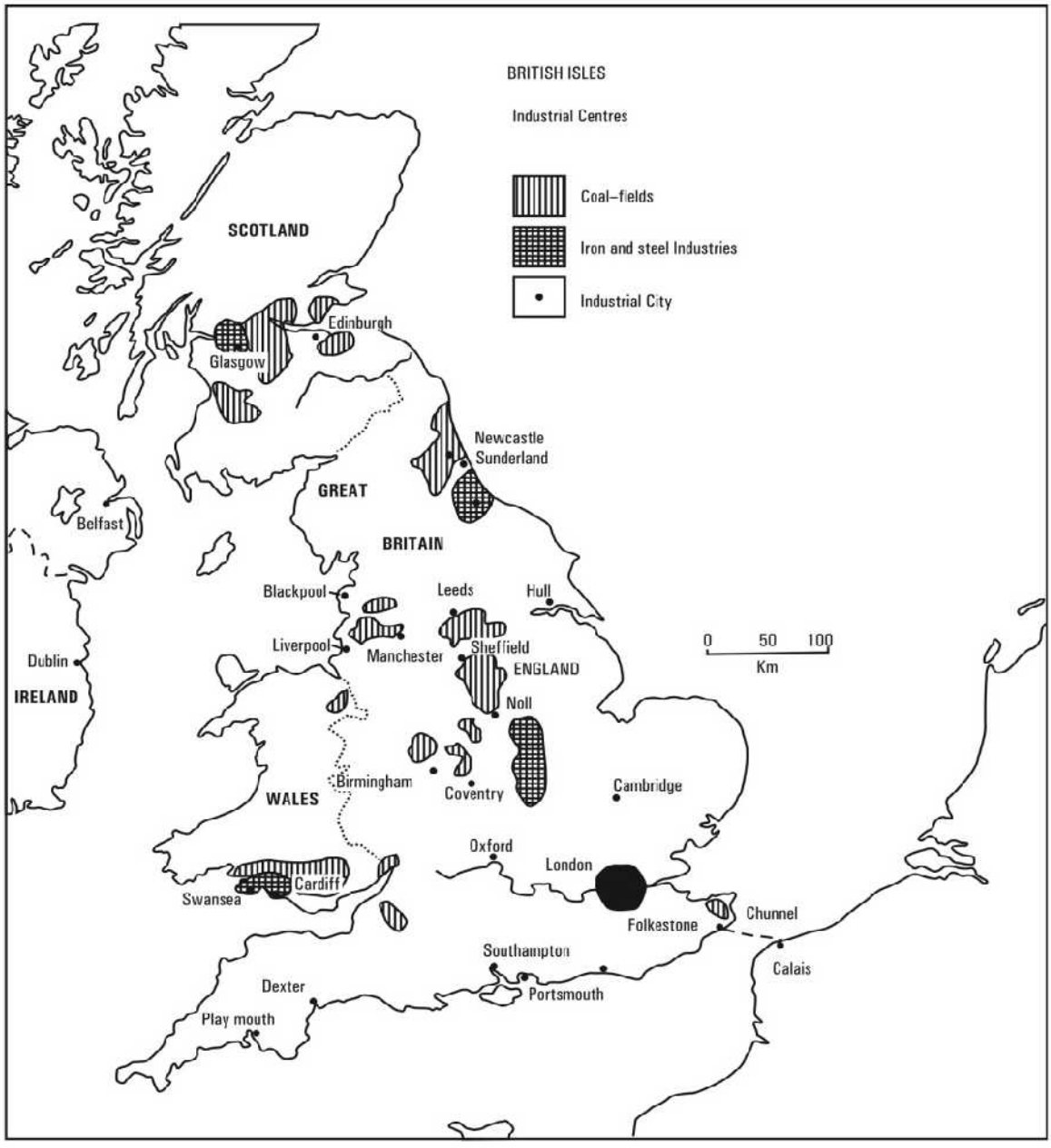

Fig. 7.27 – Industrial regions of U.K

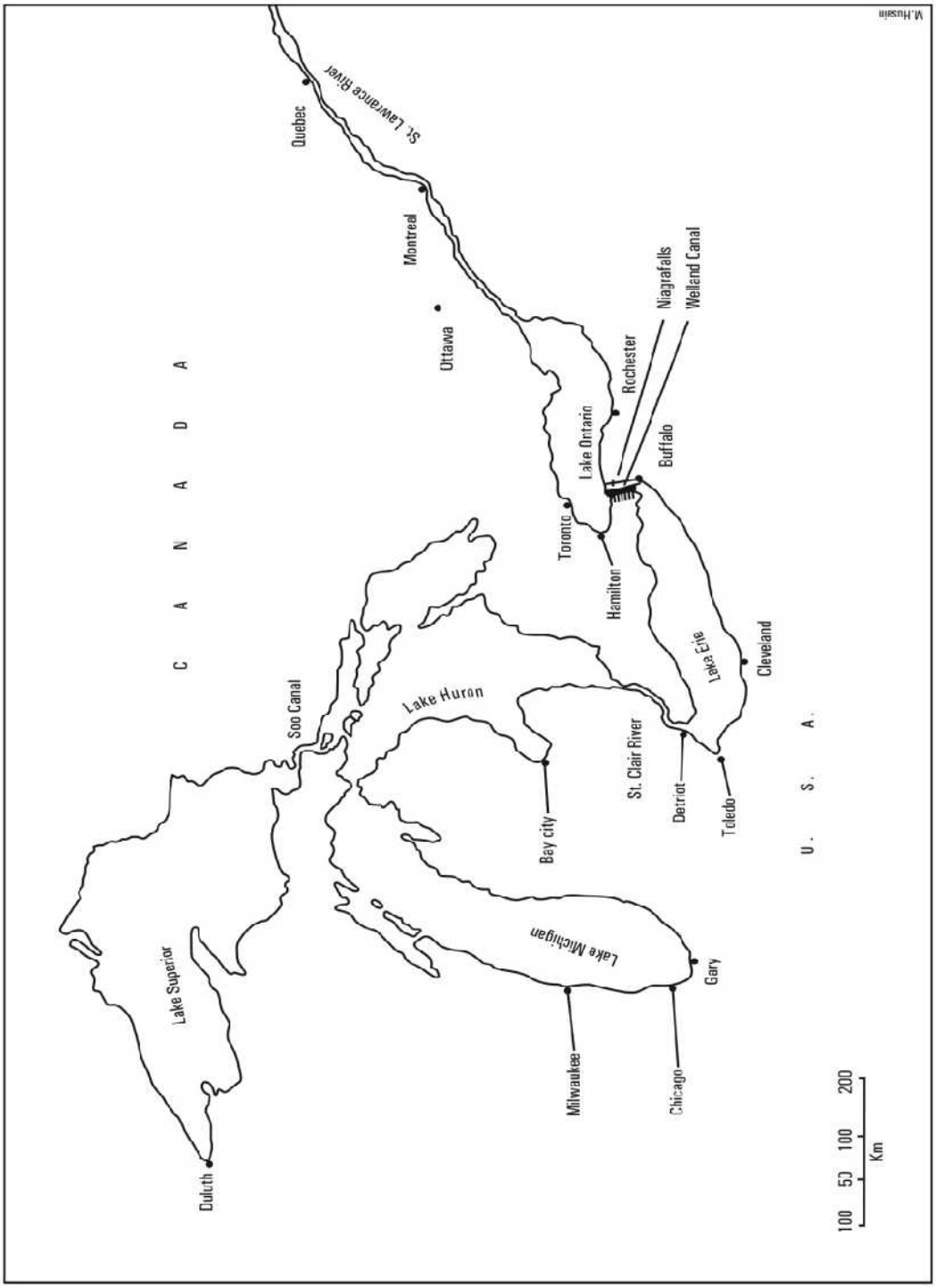

Fig. 7.28 – Industrial towns around the Great Lakes of North America

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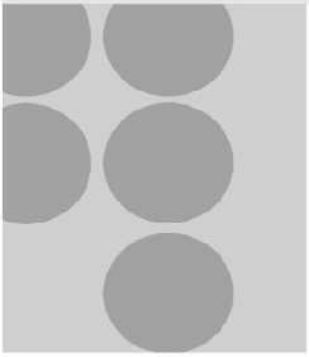
Chapter Eight

Agriculture



Chapter Concepts

- Feeding the World
- Agricultural Regions of the World
- Fishing and Forestry

Feeding the World

World agriculture is capable of providing everyone on the Earth with 2720 calories a day (more calories than the average 2100 recommended by the American Red Cross). However, 800 million people go to bed hungry every night.

Staple Foods

Staple foods are the major food sources of a particular region. They are typically energy rich, inexpensive, and easy to maintain over a long period of time. Most of the world's people rely on grains such as rice, wheat, oats, or millets as their main food source. In humid tropical and subtropical regions, root crops such as cassava are the staple foods.

Starvation

Starvation occurs when a person gets too little food to eat. On the other hand, malnutrition occurs when the body lacks certain nutrients or takes in too much unhealthy food. You can eat three meals a day and still be malnourished. World hunger affects one in seven people. War, drought and other natural disasters, and disease escalate world hunger by destroying crops and killing heads of households.

Absolute Poverty

Absolute poverty that is poverty that threatens a person's life. In global terms, this is a household earning less than the equivalents of US $1 a day. Disease hunger, and child labour plague people living in absolute poverty.

Relative Poverty

Relative poverty is having fewer resources than others in a community or country. Countries define their national poverty lines differently.

Agricultural Regions of the World

The first agricultural systems of the world were delineated by D. Whittlesey in 1936. He employed the following five criteria for the

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demarcation of world agricultural regions, namely:

(1) crop and livestock combination

(2) intensity of land use

(3) processing and marketing of farm produce

(4) degree of mechanisation, and

(5) association of buildings and other structures associated with agriculture.

The agricultural regions of the world as delineated by Whittlesey have been given in **Fig. 8.1.**

1. **Subsistence Nomadic Herding**: Nomadic herding is an ecological or near ecological system of agriculture. It is carried on mainly to produce food for the family and to fulfill the needs of clothing, shelter and recreation. It is the most simple form of pastoralism. The nomadic herders are dependent on sheep, goats, camels, horses, and reindeers. The duration of stay of the nomads at one place and direction of their movement are governed by the availability of water and natural forage **(Fig. 8.2).**

At present, nomadic herding is mainly confined in Saharan Africa (Mauritania, Mali, Niger, Chad, Sudan, Libya, Algeria), the southwestern and central parts of Asia (Iran, Iraq, Jordan, Kuwait, Kazakhstan, Kirghizia, Oman, Saudi Arabia, Syria, Turkmenistan, and Yemen) , the northern parts of Asia (Norway, Sweden, Finland and Russia). Owing to harsh climate, these areas are unsuitable for cultivation. In the desert areas, the food of nomads is mostly of animal origin (milk, cheese, curd, butter, meat, etc.), while in the sub-Arctic regions, the Eskimos, Inuits, Lapps, and Yakuts, are dependent on reindeers, fish, etc. The population of nomadic herders is, however, decreasing and areas dominated by them in the past are shrinking. It appears that true nomadism is likely to survive only in few pockets of small isolated areas of the above mentioned regions.

2. Livestock Ranching: Livestock ranching is carried on in the region with relatively flat surface and plains where grass grows luxuriously. It is mostly practised in the temperate and tropical grasslands steppes (Eurasia), praries (North America), pampas (Argentina and Uruguay), velds (South Africa), downs (Australia), savanna (Sudan), llanose (Venezuela), and compose (Brazil). The leading areas of commercial grazing are the grasslands of North America, South America, Australia, New Zealand, and South Africa.

The prairies grasslands have thousands of ranches with more than 1000 acres each. The cattle include white-faced Hereford cattle breed, the black and white Friesian cows, the Jersy cows and the superior breeds of sheep. Every year millions of cattle and sheep are fattened and transported to large slaughter houses **(Fig. 8.3)**.

3. Shifting Cultivation (Slash and Burn or Jhuming): The history of shifting cultivation is as old as the history of agriculture. Shifting cultivation is a primitive form of soil utilisation. It is practiced usually in the tropical rain forests **(Figs. 8.4 and 8.5).** Following are the main characteristics of shifting cultivation:

(i) Land belongs to the community.

(ii) Farmers grow crops for the family consumption.

(iii) It is done with fire, digging sticks, hoe and sackle.

(iv) There is no use of draught animals.

(v) No use of manures and fertilizers.

(vi) Mixed cropping (about a dozen of crops are sown mixed).

(vii) The settlements are fixed, but the fields are rotated after almost every year.

(viii) The rotation cycle of fields varies from 10 to 25 years.

(ix) The intensity of agriculture is very low.

(x) It is a great catalytic force for community life. The basic axiom of shifting cultivators is *from each according to his capacity and to each according to his needs.*

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4. Intensive Subsistence Agriculture: Subsistence agriculture is a type of farming in which crops grown are consumed by the grower and his family. It is mostly done in the countries of Monsoon Asia and Africa (**Fig. 8.6**). The main characteristics of intensive subsistence agriculture are as under:

(i) Small size of holding
(ii) Small size of fields
(iii) Scattered fields
(iv) Use of draught animals
(v) Use of domestic labour
(vi) Dominance of cereal crops
(vii) General indebtedness

5. Plantation Agriculture

The term 'plantation agriculture' was originally applied specifically to the British settlements in America and then to any large estate in North America, West Indies and South East Asia which was cultivated mainly by Negro and other coloured labourers from Asia and Africa. Plantation agriculture is practiced in the hot and humid subtropical regions of the world (**Fig. 8.7**).The main characteristics of plantation agriculture are:

(i) It is practised mainly in the tropical countries to grow cash crops.
(ii) The size of plantation estates is generally large.
(iii) It is a specialised commercial cultivation.
(iv) Land in plantation agriculture is devoted to rubber, oil-palm, copra, cotton, tea, coffee, hemp, spices, cocoa, pineapple, banana, sugarcane hemp and jute.
(v) It is executed with specialised skill, and wherever, possible with the application of machinery.
(vi) There is heavy application of fertilizers, insecticides and pesticides.
(vii) It aims at high yields.
(viii) In most of the plantation estates there are factories to produce the marketable products.
(ix) It is largely based on the exploitation of cheap labour.
(x) The final product have to be fully processed and standardised to meet the world demand and specifications.

6. Extensive Agriculture

Extensive agriculture is carried on in the mid-latitudes, well away from maritime influence, recording less than 60 cm of rainfall. It is best developed in the steppes of Russia, Central Asia, Central and Western Plains of North America. Following are the main characteristics of extensive agriculture:

(i) It is highly mechanised.
(ii) The size of holdings is large, ranging from 240 to 16,000 hectares.
(iii) It employs little labour.
(iv) The per hectare yield is low.
(v) It is practiced in the sparsely populated areas.
(vi) Monoculture of wheat is the dominant cropping pattern. Among other crops, barley, oats, rye, flax and oilseeds are important.

7. Mediterranean Agricultural System

This type of agriculture is confined to the coastal areas of Mediterranean Sea in Europe, Asia Minor, California, Central Chile, Cape Province of South Africa and south-west of Western Australia including Tasmania. The main characteristics of Mediterranean agriculture are:

(i) Specialise in the orchards of citrus fruits. Cereals are subordinated to tree crops.
(ii) Wheat and barley are the main crops during the winter season.
(iii) The size of holdings vary from medium to large.
(iv) The shape of fields is irregular.
(v) Irrigation is done specially during the summer season.
(vi) Vines, figs, olive, etc. occupy a significant part of the agricultural land.

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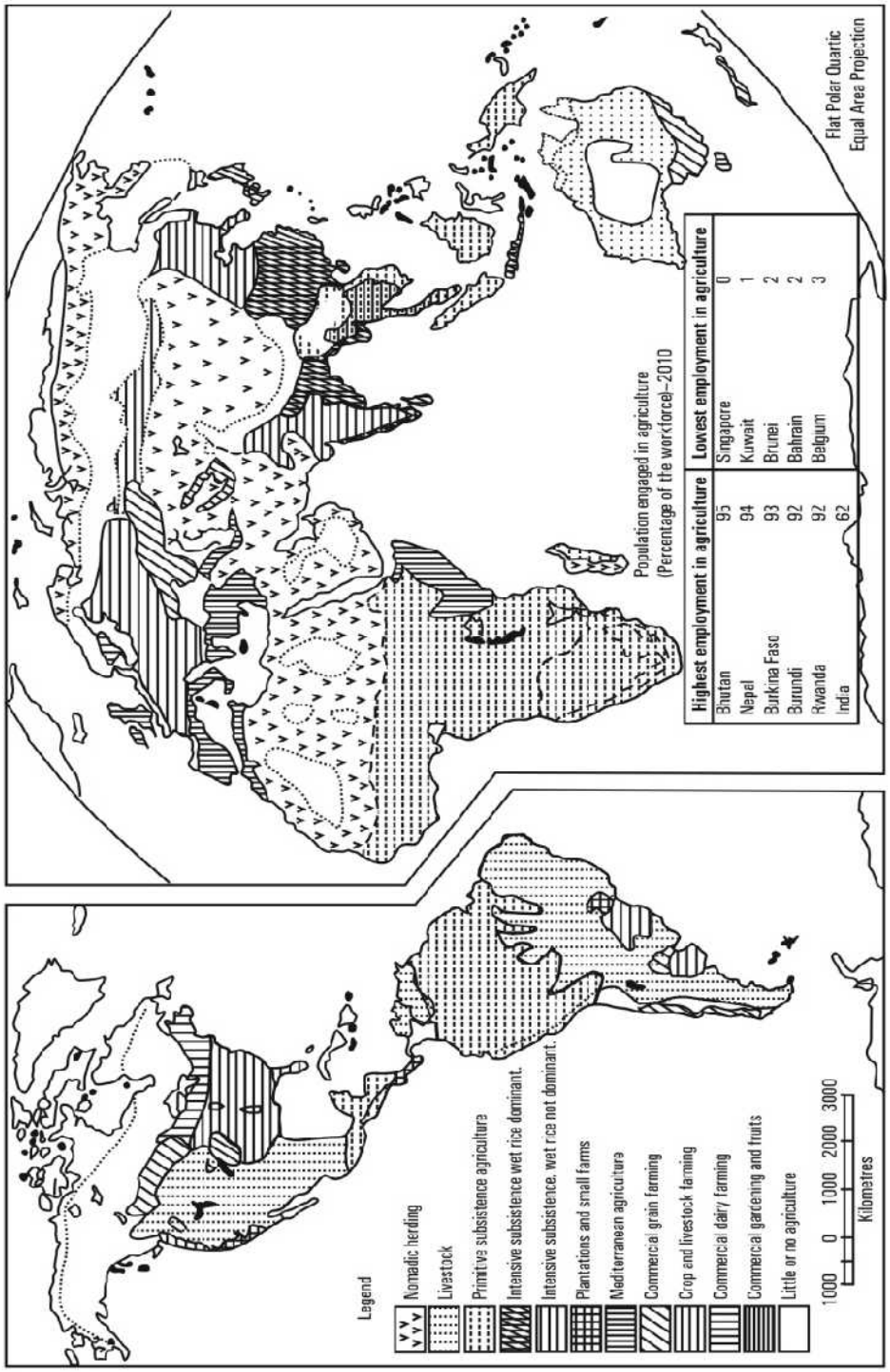

Fig. 8.1 – World Agricultural regions (after D.Whittlesey)

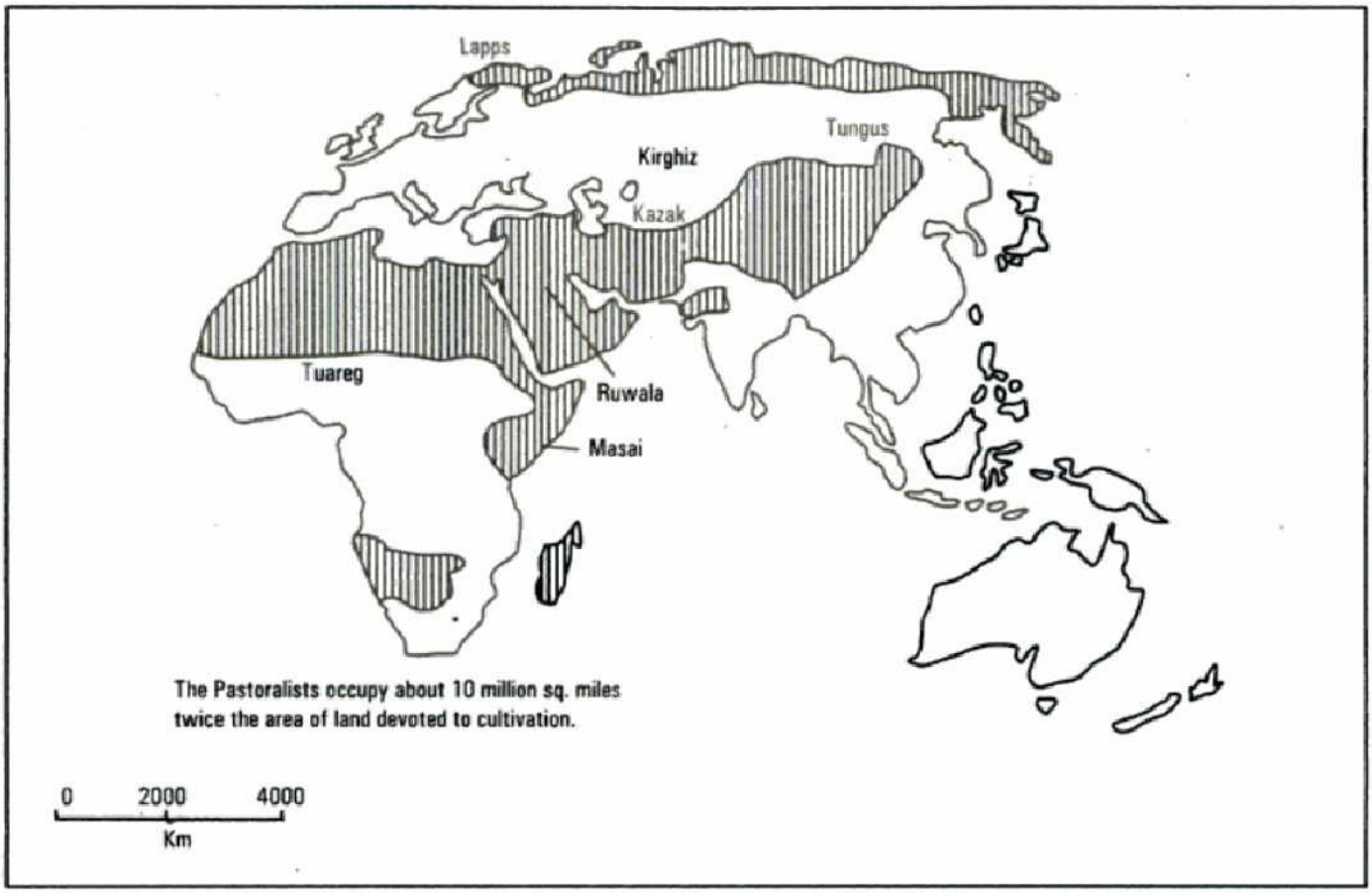

Fig. 8.2 – Subsistence Nomadit Herding

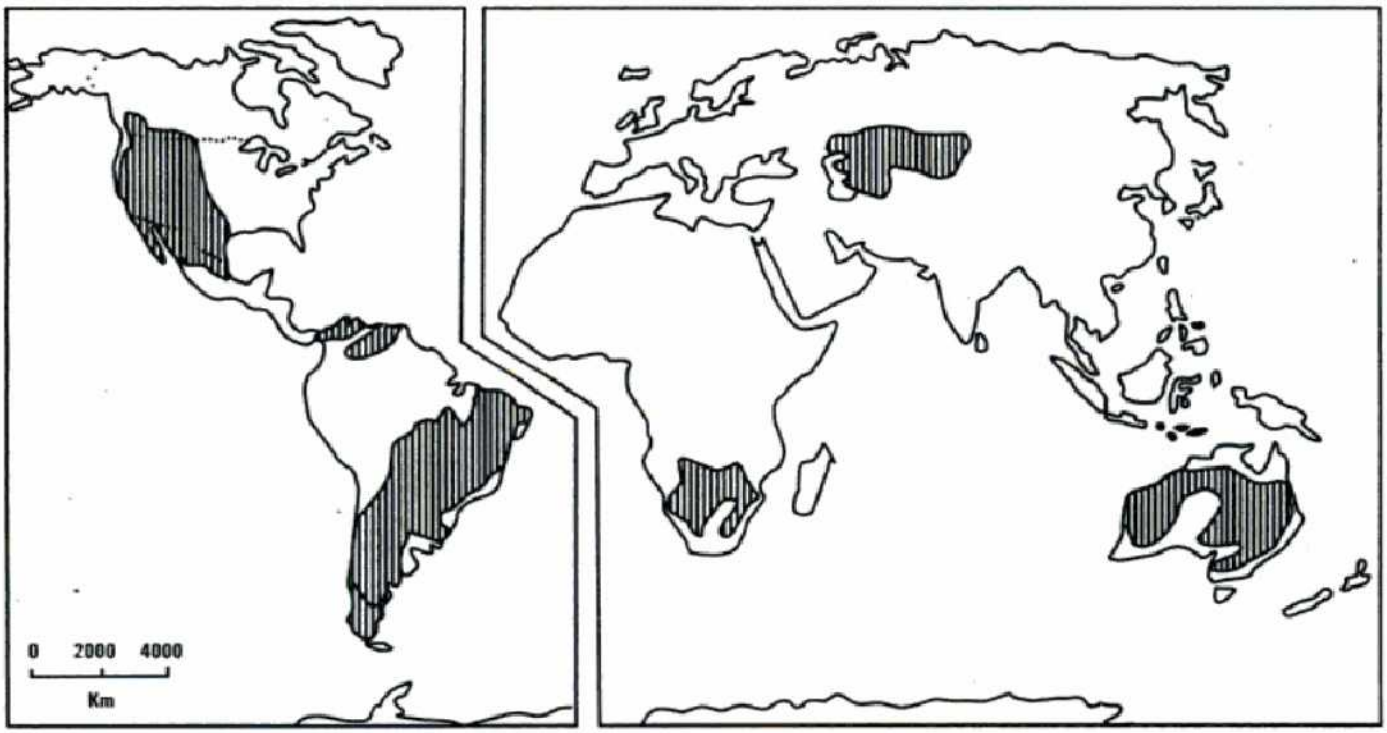

Fig. 8.3 – Livestock ranching

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Fig. 8.4 – Shifting cultivation

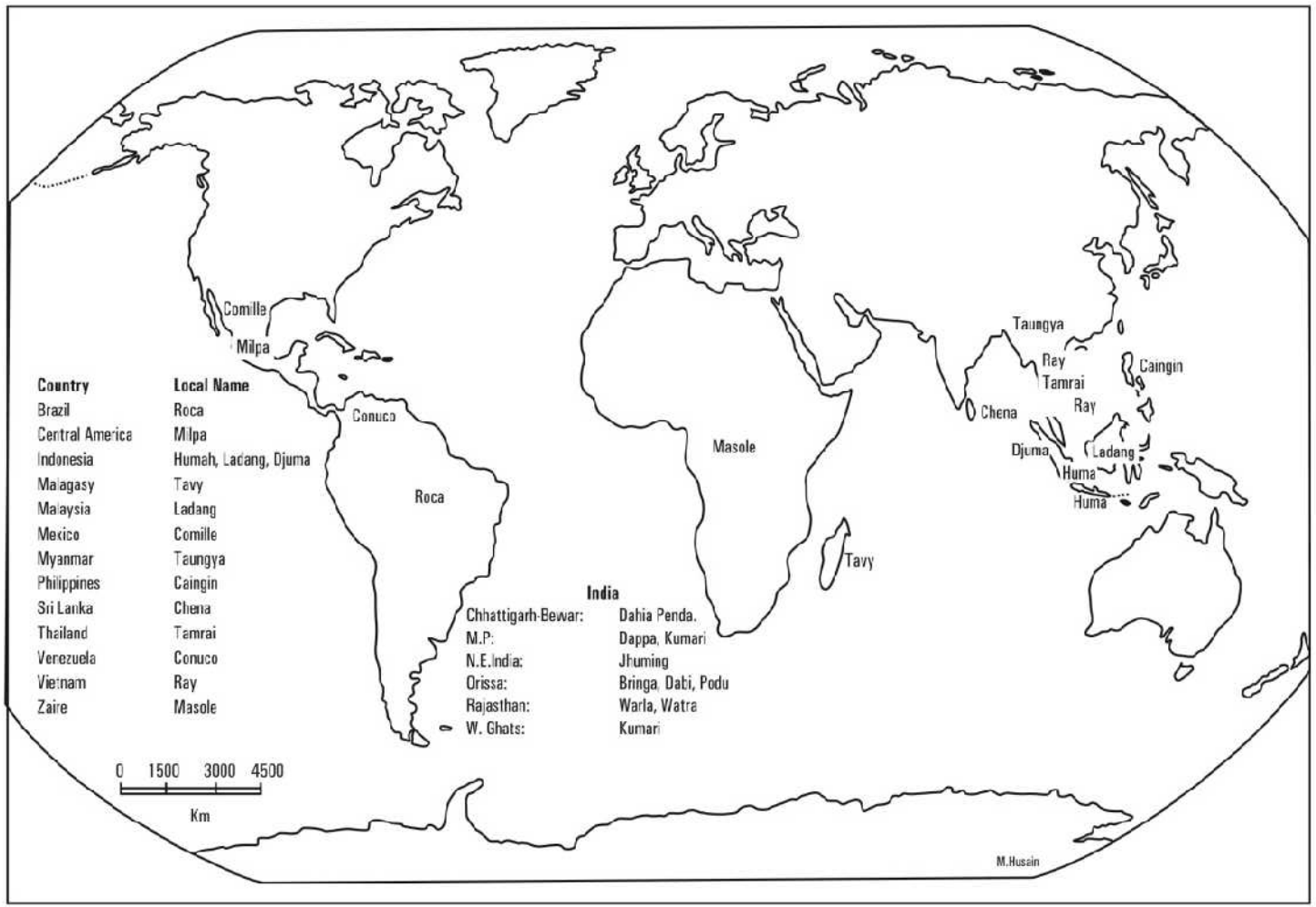

Fig. 8.5 – Local names of shifting cultivation

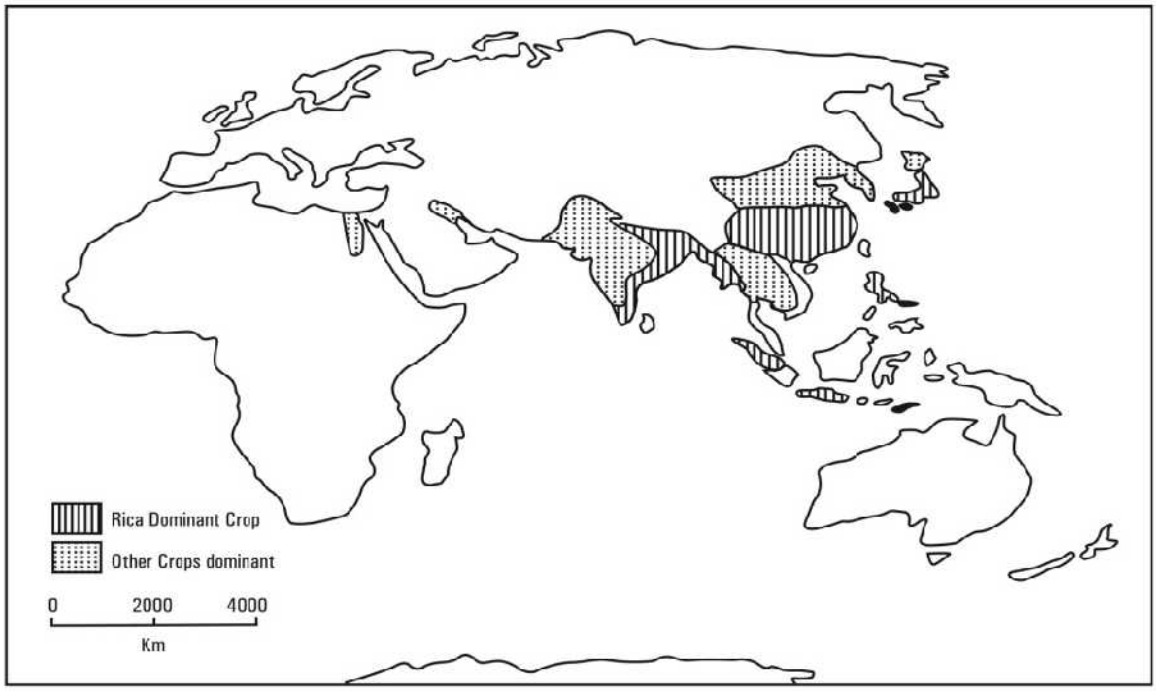

Fig. 8.6 – Intensive subsistence agriculture

(vii) In the hilly areas sheep rearing is common.

(viii) In general the farming community is well off.

8. Mixed Farming or Commercial Crops and Livestock: Mixed farming is a type of agriculture which involves both crops and livestock. It is found throughout Europe including Eurasia, North America (east of 90° longitude). The main characteristics of mixed farming are given below:

(i) It is practiced in the densely populated and urbanised regions of the temperate latitudes.

(ii) The size of holdings is large.

(iii) It is highly mechanised.

(iv) It yields high agricultural returns.

(v) Crops are grown to be fed to livestock, pigs and poultry.

(vi) Agricultural land is devoted to fodder (hay) and maize crops.

(vii) In winter season, forage crops, hay, solid feed and concentrates are fed to livestock.

(viii) The livestock require daily attention of the farmers.

(ix) The wages of labour are high, which made this increasingly difficult to keep a variety of livestock on the farms.

(x) The per capita income and the standard of living of the of mixed farmers are high.

9. Dairy Farming: The keeping of cattle for milk and milk products (butter, cheese, curd, condensed and powder milk) is known as dairy farming. It is practised mainly in the temperate countries of Europe, North and South America, South Africa, Australia and New Zealand. The main characteristics of dairy farming are given below:

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Fig. 8.7 – World – Major plantation crops.

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Fig. 8.8 – Main rice producing regions of the world

(i) Dairying is a capital intensive farming. It needs huge amount to develop the infrastructure for livestock.

(ii) It is highly mechanised.

(iii) It needs long hours for the farmers to look after the cows.

(iv) There is a fixed ratio of cattle and arable land. For example, in Britain the ratio is one cow per acre.

(v) Dairying fetches handsome amount to the farmers. Consequently, the standard of living of the dairy farmers is fairly high.

10. Horticulture (Truck Farming)

Specialised cultivation of vegetables, fruits and flowers is known as horticulture or truck farming. It is practiced mainly in the highly industrialised, urbanised regions of North East USA, Canada (Lakes Region), and in the suburbs of the metropolitan regions of North-West Europe, Europe, Australia and New Zealand. In urbanised districts of the developed countries, there is a heavy demand of vegetables and fruits. The main characteristics of this type of farming are given below:

1. The size of holdings is relatively small.
2. These orchards are well connected by metalled roads.
3. The truck farms are generally at an over night distance from the markets.
4. It is a capital intensive and highly mechanised type of farming.
5. This type of agriculture is done on scientific lines.
6. Harvesting of vegetables and fruits is done manually.

Table 8.1: *Major Crops of the World*

Crop	*Geographical Conditions Required*	*Leading Producers*
Rice	Temp.20°-25° C; rainfall minimum 100 cm; Clayey soil	China, India, Indonesia, Bangladesh, Thailand, Japan, Myanmar, Vietnam, Malysia. Leading exporter in the world: Thailand **(Fig. 8.8)**.
Wheat	Temp.10°C to 25°C; rainfall 50-75 cm; Loamy well drained soil.	China, India, U.S.A., Russia, Australia, Canada, France, Turkey. Leading exporter in the world: USA. **(Fig. 8.9).**
Barley	Temp.10° to 25°C; rainfall 50 to 75 cm; Well drained loamy soil.	Russia, China, Canada, USA, France, U.K., Germany, Turkey. Leading exporter in the world: Russia **(Fig.8.10).**
Maize	Temp. 15°C to 25°C; rainfall 40-75 cm; Well drained loamy soil.	U.S.A., China, Brazil, Mexico, Russia, Romania, India, South Africa. Leading exporter in the world USA **(Fig. 8.11).**
Millet	Temp. 20° to 27°C; rainfall 50 to 75 cm; Well drained loamy soil.	China, U.S.A., India, Nigeria, Ukraine, Thailand, Russia, Turkey. Leading exporter in the world: USA **(Fig. 8.12).**
Soybean	Temp. 15° to 22°C; rainfall 20 to 60 cm; Well drained loamy soil.	China, U.S.A., Brazil, Argentina, Ukraine, Japan, Russia, Columbia. Leading exporter in the world U.S.A **(Fig. 8.13).**

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Sugarbeet	10° C to 20°C; rainfall 40 to 50 cm; Well drained loamy soil.	France, USA, Germany, Russia, China, Ukraine, Poland, Turkey. Leading exporter in the world: France **(Fig. 8.14).**
Cotton	Temp. 18° C to 25°C; rainfall 50 to 75 cm; Frost free days 180.	China, USA, India, Brazil, Pakistan, Uzbekistan, Egypt, Turkey. Leading exporter in the world: USA **(Fig. 8.15).**
Rubber (Natural)	Temp. 22°C to 27°C; rainfall 150 to 200 cm; Well drained alluvial soil.	Thailand, Indonesia, Malaysia, India, China, Sri Lanka, Liberia, Brazil. Leading exporter in the world: Thailand **(Fig. 8.16).**
Tea	Temp. 15° to 25°C; rainfall 100 to 150 cm; Well drained soil on the hilly slopes.	India, China, Sri Lanka, Japan, Kenya, Indonesia, Bangladesh, Turkey. Leading exporter: India **(Fig. 8.17).**
Coffee	Temp. 20°C to 25°C; rainfall 100 to 150 cm; Well drained alluvial soil.	Brazil, Columbia, Indonesia, Vietnam, Ivory Coast, Mexico, Ghana, Cameroon. India, Leading exporter in the world: Brazil **(Fig. 8.18).**
Cocao	Temp. 20°C to 27°C; rainfall 150 to 200 cm; Well -drained alluvial soil.	Ivory-Coast, Ghana, Indonesia, Brazil, Cameroon, Nigeria, Ecuador, Costa-Rica. Leading exporter in the world: Ivory-coast **(Fig. 8.19).**
Tobacco	Temp. 18° to 25°C; rainfall 75 to 100 cm; Well drained alluvial soil.	China, U.S.A., India, Brazil, Turkey, Japan, Bulgaria, South Korea. Leading exporter in the world: USA **(Fig. 8.20).**
Groundnut	Temp. 20° C to 25°C; rainfall 50 to 75 cm; Well drained loam to sandy loam.	India, China, U.S.A., Sudan, Senegal, Indonesia, Argentina, Myanmar. Leading exporter in the world: USA **(Fig. 8.21).**
Apple	Temp. 15°C to 20°C; rainfall 50 to 100 cm; Well drained alluvial soil.	USA, France, Italy, Spain, Mexico, India, Argentina, Turkey, Russia, Greece. Leading exporter in the world: USA **(Fig. 8.22).**
Banana	Temp. 18°c to 25°C; rainfall 100 cm; Well drained alluvial soil.	Brazil, Costa Rica, India, Mexico, Honduras, Leading exporter in the world: Costa Rica **(Fig. 8.22).**
Grapes	Temp. 15° to 20°C; rainfall 60 cm; Well drained alluvial soil.	Spain, France, Russia, Italy, USA, Chile, Argentina, Algeria, Greece. Leading exporter in the world: France **(Figs. 8.23 & 8.24).**

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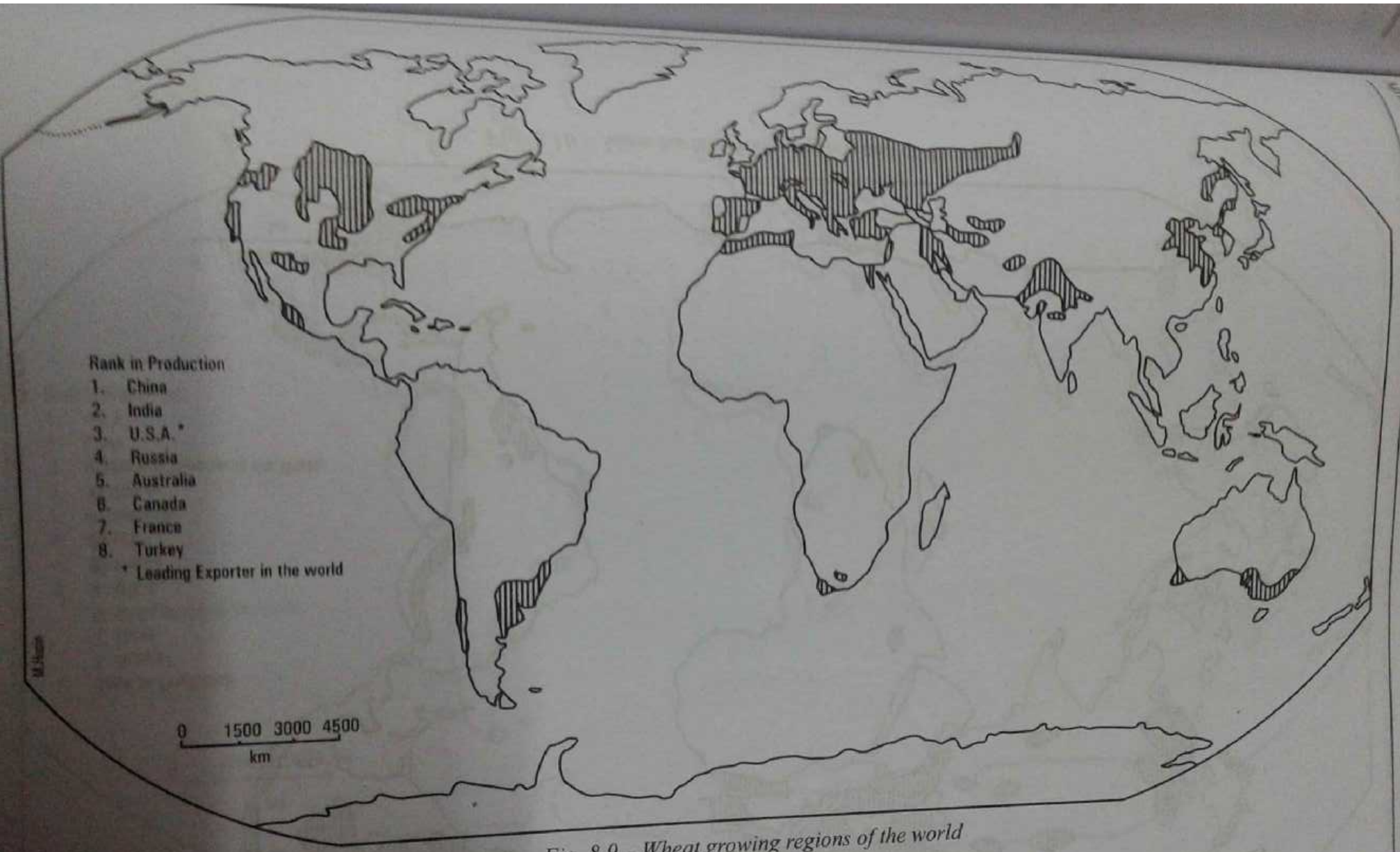

Fig. 8.9 – Wheat growing regions of the world

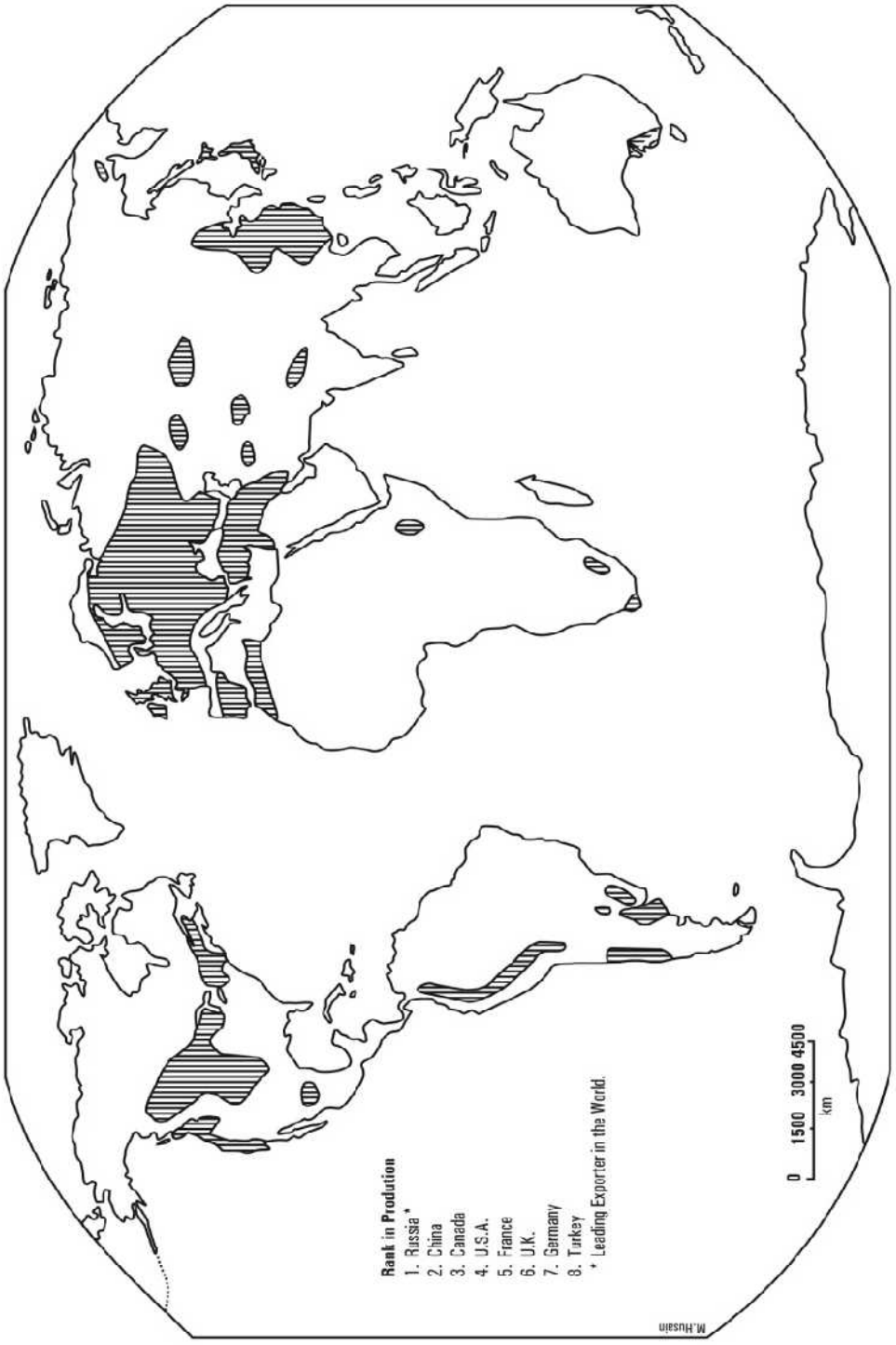

Fig. 8.10 – Main barley producing regions of the world

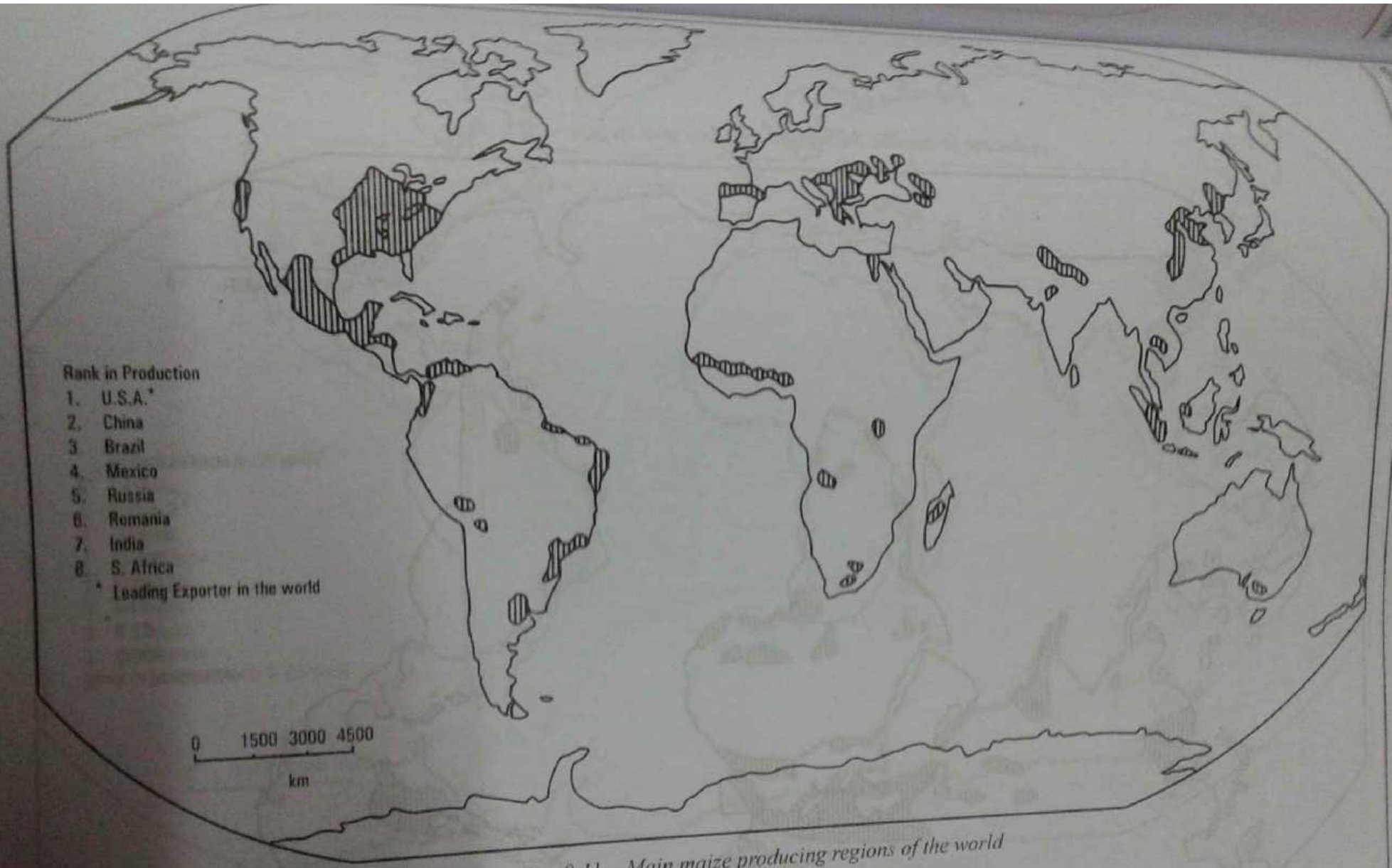

Fig. 8.11 – Main maize producing regions of the world

Fig. 8.12 – Millets and sorgham producing regions of the world

Fig. 8.13 – Soybean producing regions of the world

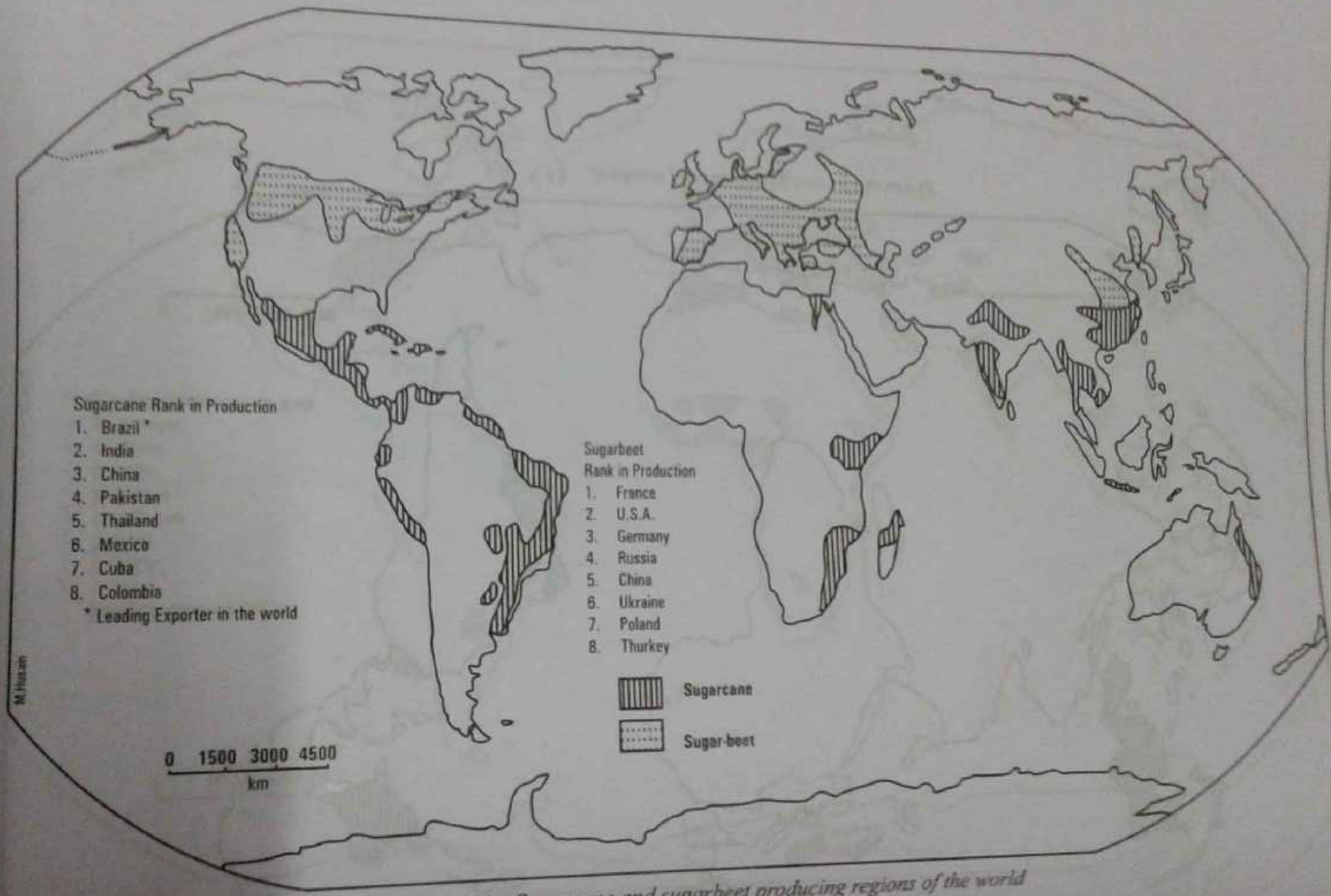

Fig. 8.14 – Sugarcane and sugarbeet producing regions of the world

Fig. 8.15 – Cotton producing regions of the world

Fig. 8.16 – Natural rubber producing regions of the world

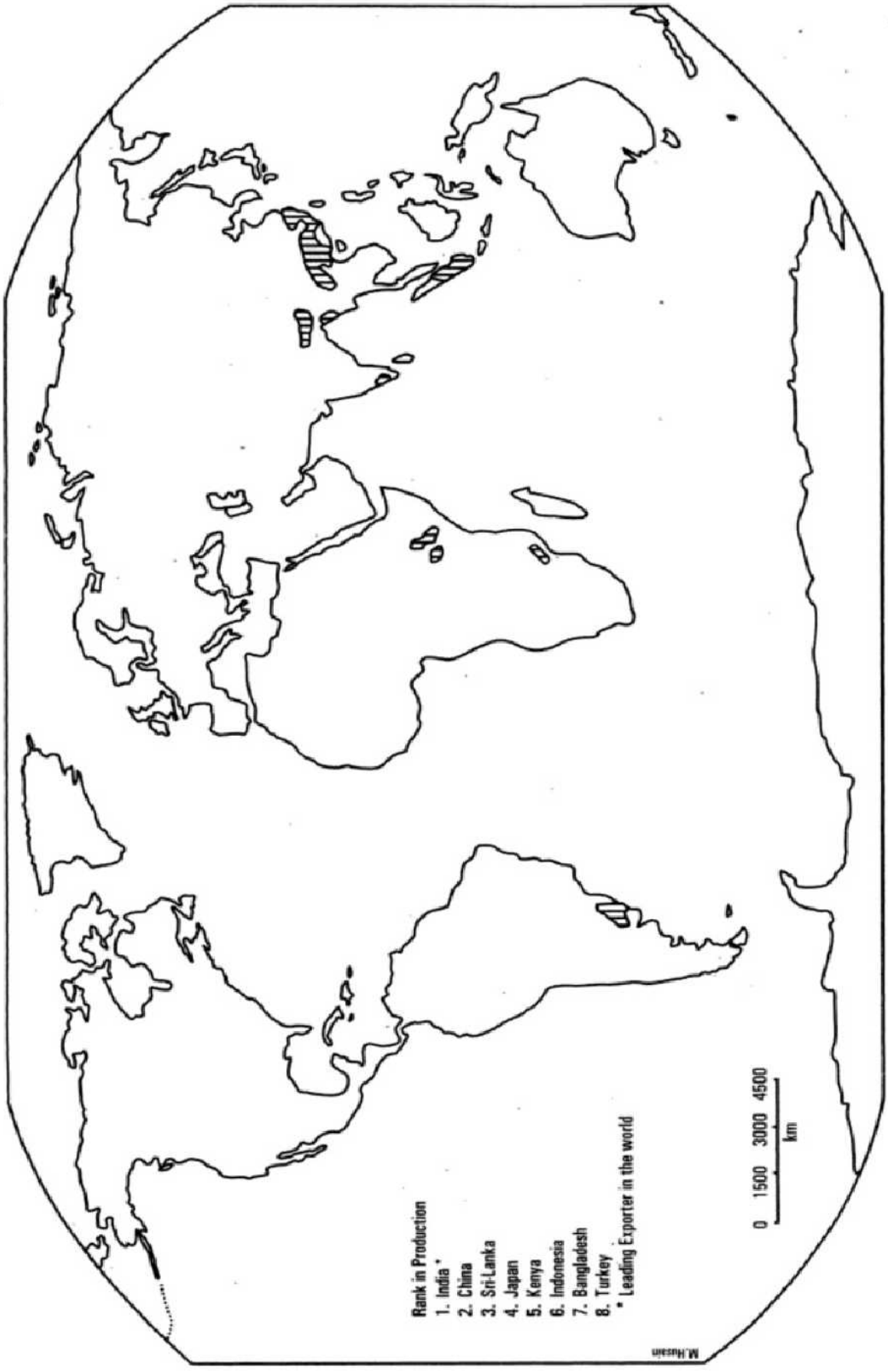

Fig. 8.17 – Tea producing regions of the world

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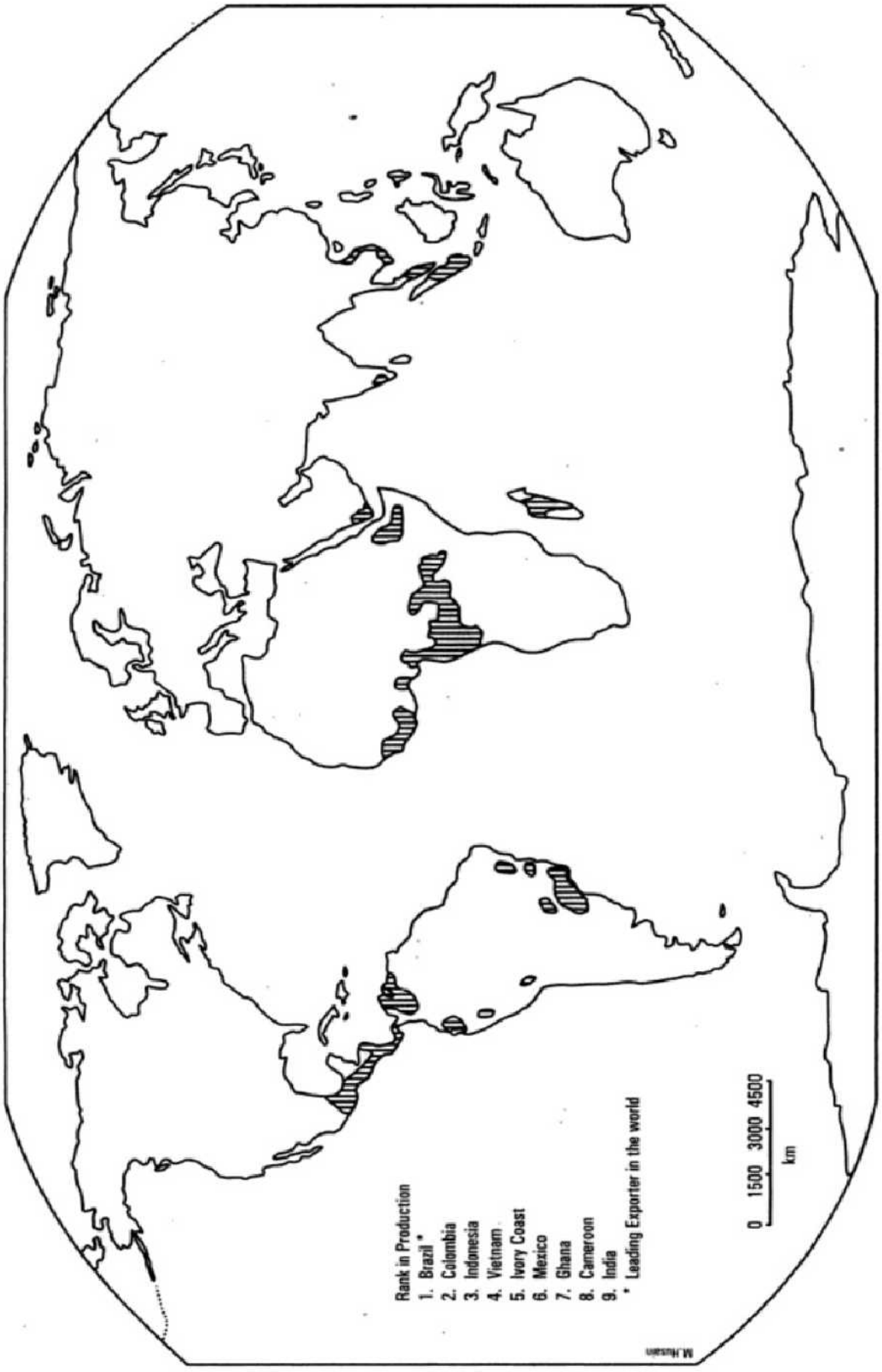

Fig. 8.18 – Coffe producing regions of the world

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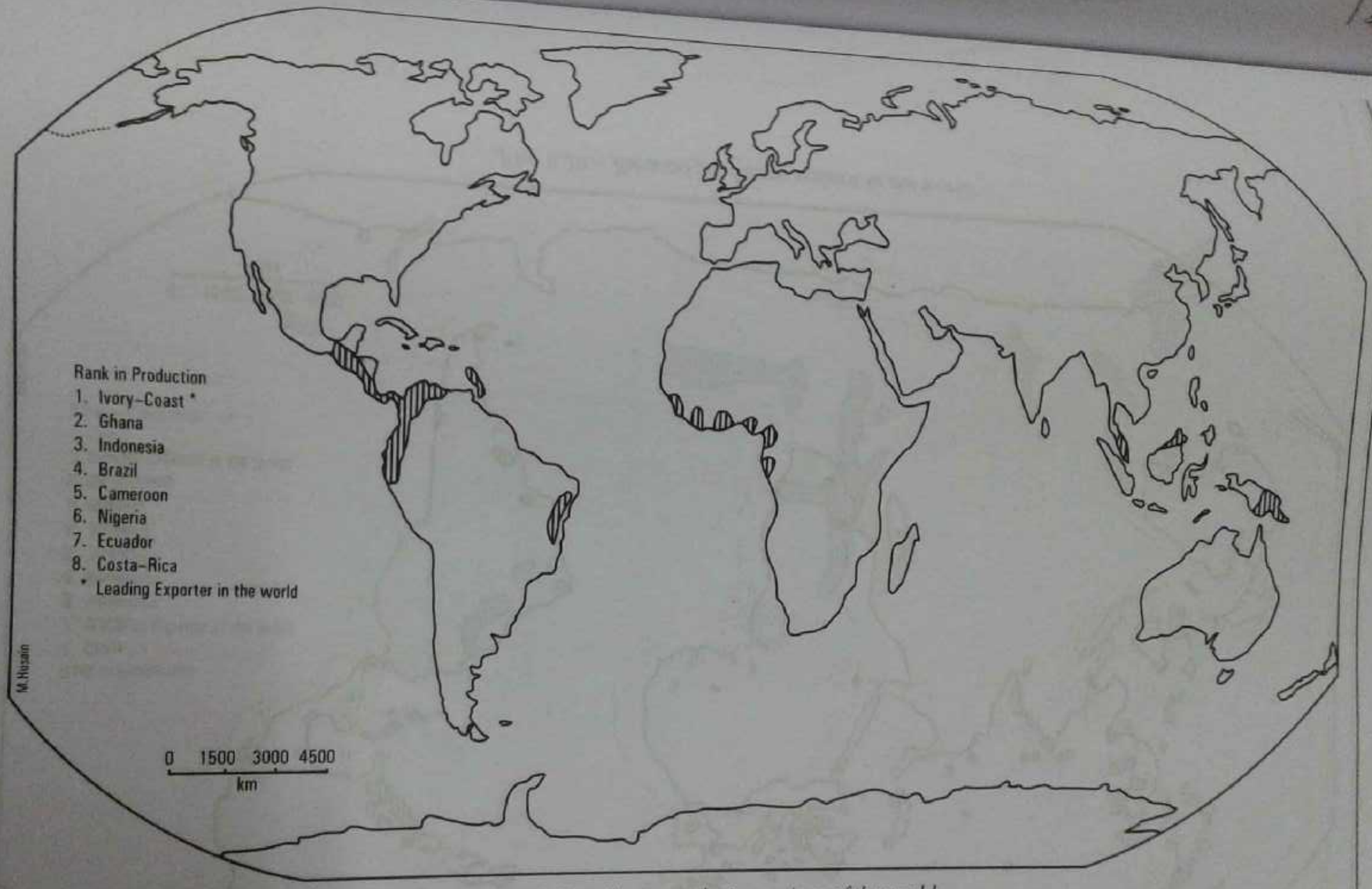

Fig. 8.19 – Cocao producing regions of the world

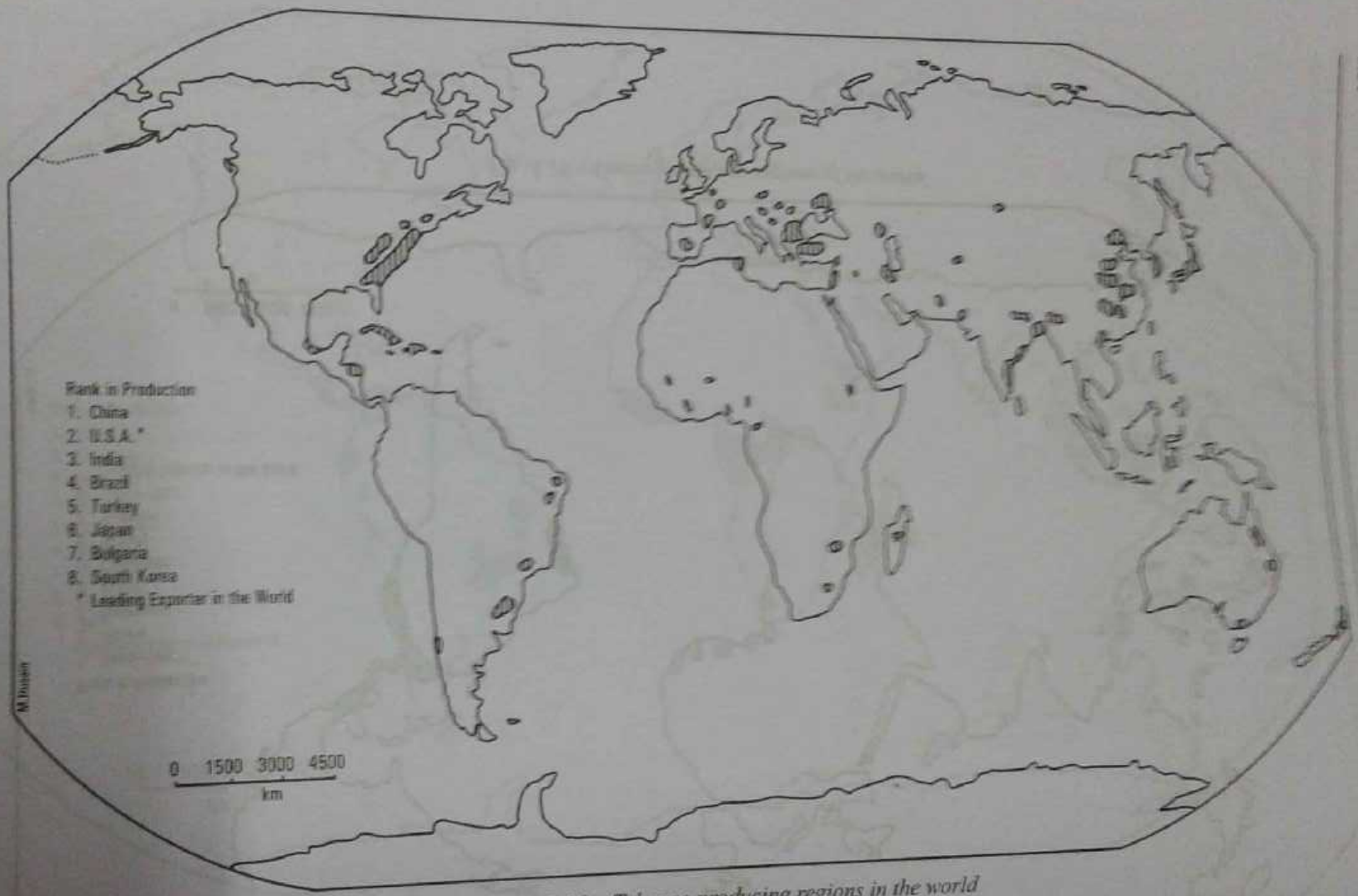

Fig. 8.20 – Tabacco producing regions in the world

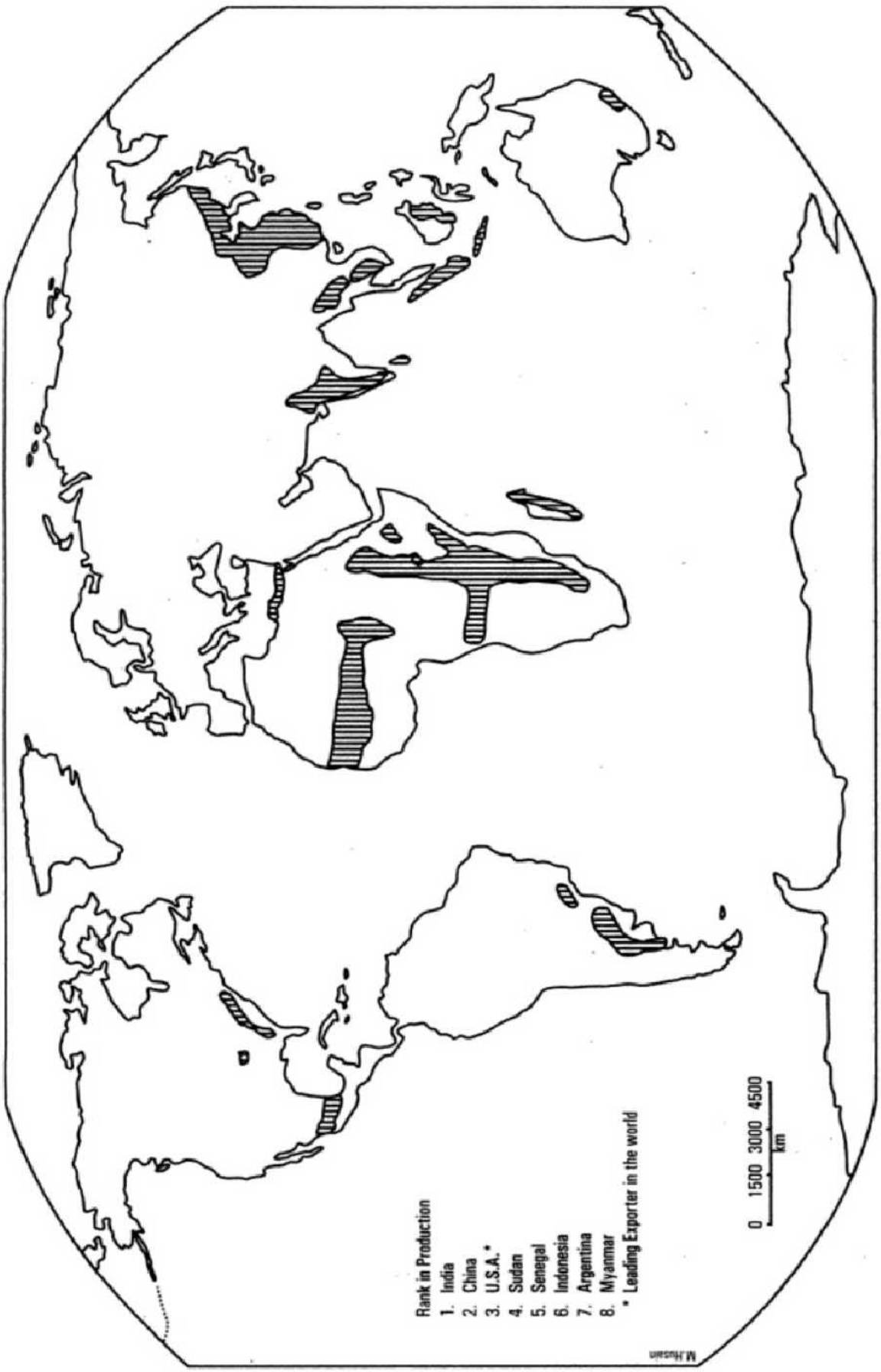

Fig. 8.21 – Groundnut producing regions in the world

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Fig. 8.22 – Apple and banana producing regions in the world

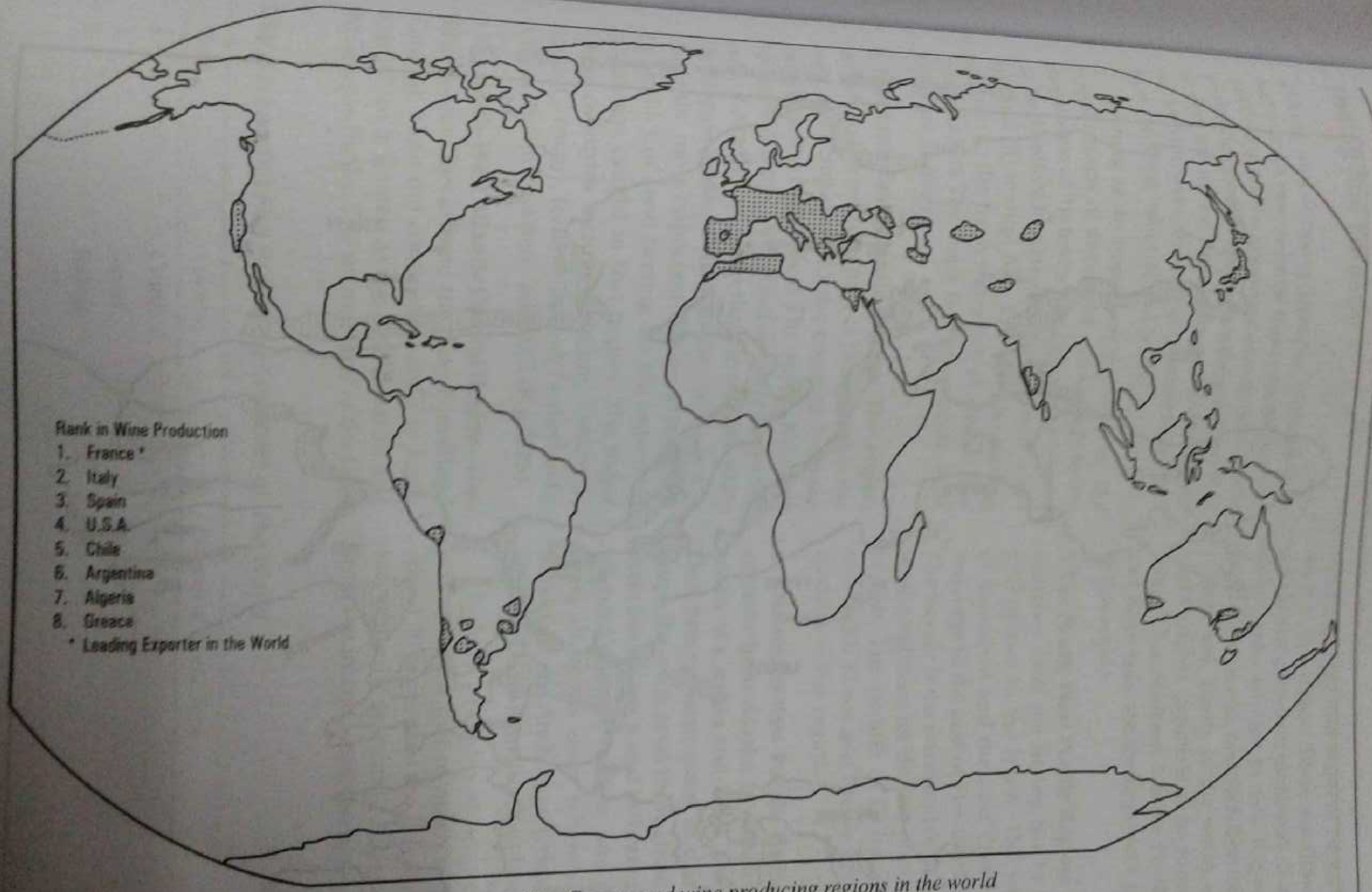

Fig. 8.23 – Grapes and wine producing regions in the world

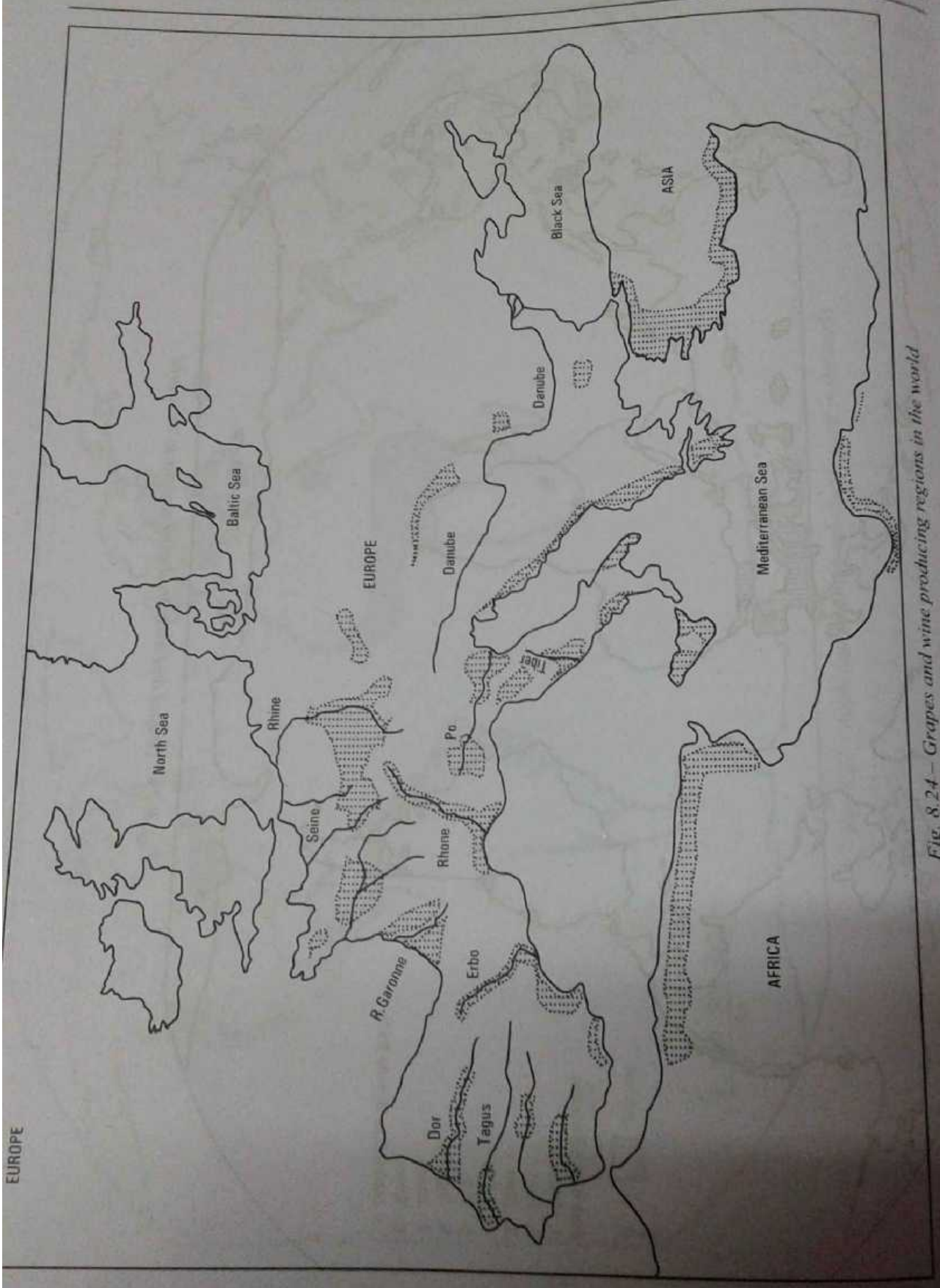

Fig. 8.24 – Grapes and wine producing regions in the world

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Fishing and Forestry

Fishing and forestry involve gathering or harvesting a raw material from nature. Forestry and fishing are the important economic activities providing employment for a substantial number of persons in the developing and developed world. Moreover, they are important sources of food, building material and trade.

Fishing is an important economy in the coastal regions of the world particularly in the coastal areas of the temperate latitudes. Fisheries can be classified into two groups: (i) fresh water fish, and (ii) marine fish. China is the leading producer in the fresh water fish as well as that of marine fish. The major fishing grounds of the world are as under:

1. The North East Atlantic Region: This region extends to the western part of Europe from the coast of Portugal up to the coast of Norway including the North Sea. The warm water of the North Atlantic Drift (Gulf-Stream) keeps the coast of North Sea open throughout the year. The Dogger Bank located in the North Sea is one of the most important fishing grounds in the world. Cod, and herring are the important fish species caught in this region. The major fishing countries include Belgium, Denmark, France, Germany, Iceland, Ireland, Netherlands, Norway, Spain, Sweden, and UK **(Fig. 8.25)**.

2. The North-West Atlantic Coastal Region: This fishing region lies around the New-Foundland (Canada). Here the continental shelf is fairly wide which is known as the Grand Banks and the Georges Banks. The warm water of the Gulf Stream and the cold water of Labrador Current meet in this region. These conditions are ideal for the fast growth of planktons. Consequently, these banks are rich in fish. The main fish of the region are cod, haddock, herring, lobsters, oysters and perch. In the warm water of the southern part, shrimp is an important catch. St. John's, Charlottetown, Halifax, Portland, Boston, and New York are the important fishing ports of this region.

3. The North-West Pacific Region: This region stretches from the Bering Sea in the north to Philippines in the south. The warm current of Kurosiwo and the cold Oyasiwo currents converge to the east of Honshu Island (Japan). The merger of the warm and cold currents create ideal conditions for the fast population growth of fish. The people of China, Japan, North and South Korea and Russia are the main fish catchers in this region.

4. The North-East Pacific Region: This zone extends from Alaska to California along the coasts of Canada and USA. The North Pacific Drift brings warm water in this region which keeps the coast open throughout the year. The main fish species found in this region are halibut, pilchard, salmon, sardine, and tuna. The main ports along the coast where fish industry is important are Anchorage (Alaska), Vancouver (Canada), San-Francisco and Los Angles (USA).

Fishery provides an important source of protein in the diet of much of the population. About 90 per cent of the fish is caught from the sea, while the remaining 10 per cent is obtained from the inland water-bodies.

Table 8.2: Leading Fish Producing Countries of the World

Rank	*Country*	*Per cent of World Total*
1.	China	14
2.	Japan	12
3.	Russia	10

4.	USA	05
5.	Norway	04
6.	Chile	04
7.	India	03
8.	South Korea	03
9.	Thailand	03
10.	Indonesia	02

Aquaculture

The commercial raising of plants and animals in water is known as aquaculture. Today aquaculture accounts for less than one per cent of world fish production. The coastal areas of China and Japan are well known for aquaculture. Fish are also raised as sideline in rice paddies in the countries of Monsoon Asia. In recent years Japanese farmers have permanently converted some rice paddies into huge dug-out tanks for fish production. In the United States, commercial production of catfish has become big business in many southern states. The future of fish in the human diet remains bright. The developing countries will begin to produce more fish for their domestic markets rather than for export.

Law of the Sea

According to the United Nations Law of the Sea Conference 1982, the territorial sea limit is 12 miles from the shore, a 24-mile contiguous zone, and a 200 mile exclusive economic zone (EEZ) as called for in the Law of the Sea Treaty. Pollution of coastal marine waters remain a threat to world fisheries. Heavy metals such as cadmium, lead, and mercury reach coastal water via river discharges in industrial areas. Moreover, oil spills are adversely affecting the aquaculture adversely.

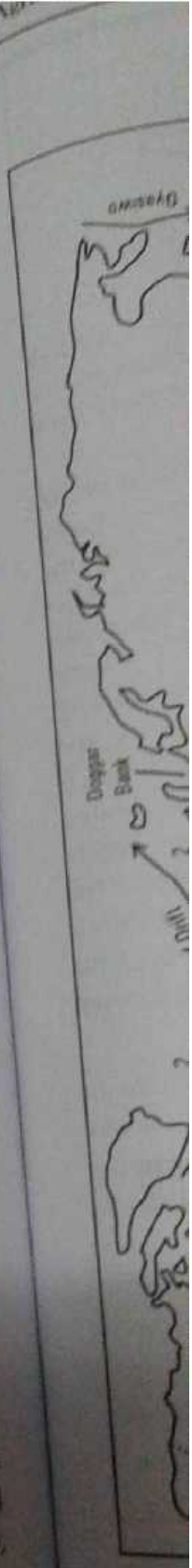
Forestry

Forestry is an important economic activity in the contemporary world. Wood is used as fuel, including cooking and heating uses, and half for industrial purposes (boards, pulp, veneer). The distributional pattern of forests have been shown in **Fig. 8.26.**

Commercial forests occur in two huge global belts as shown in **Fig. 8.26.** The first virtually encircles the world in the higher latitudes of the northern hemisphere. The second forest belt lies in the equatorial region including a large part of South America and central Africa. The main species of tropical region which are in much demand are mahogany, cedar, teak, ebony, and balsa. Moreover, commercial forest gathering is of significance in Japan, southern United States, Madagascar, Chile, Myanmar, Thailand, south-eastern Australia, New Zealand, some of the east European countries. The Amazon Basin is one of the largest equatorial forest areas of the world. The forest of Amazon Basin are known as *'Selvas'* **(Fig. 8.27).**

The tallest trees of the world grow in the fir and pine forests of northern California, where giant *redwood sequoias* attain heights of about 100 m and diameters of 6 meter. *Douglas fir* trees in California grow about 100 m. The forest resource of mid-latitudes hardwood deciduous tree include oak, chestnut, hickory, maple, birch, and beech trees.

The leading producers of industrial timber include United States, Russia, and Canada while India is the leading producer of fuelwood followed by Brazil and China **(Table 8.3), (Table 8.4).**



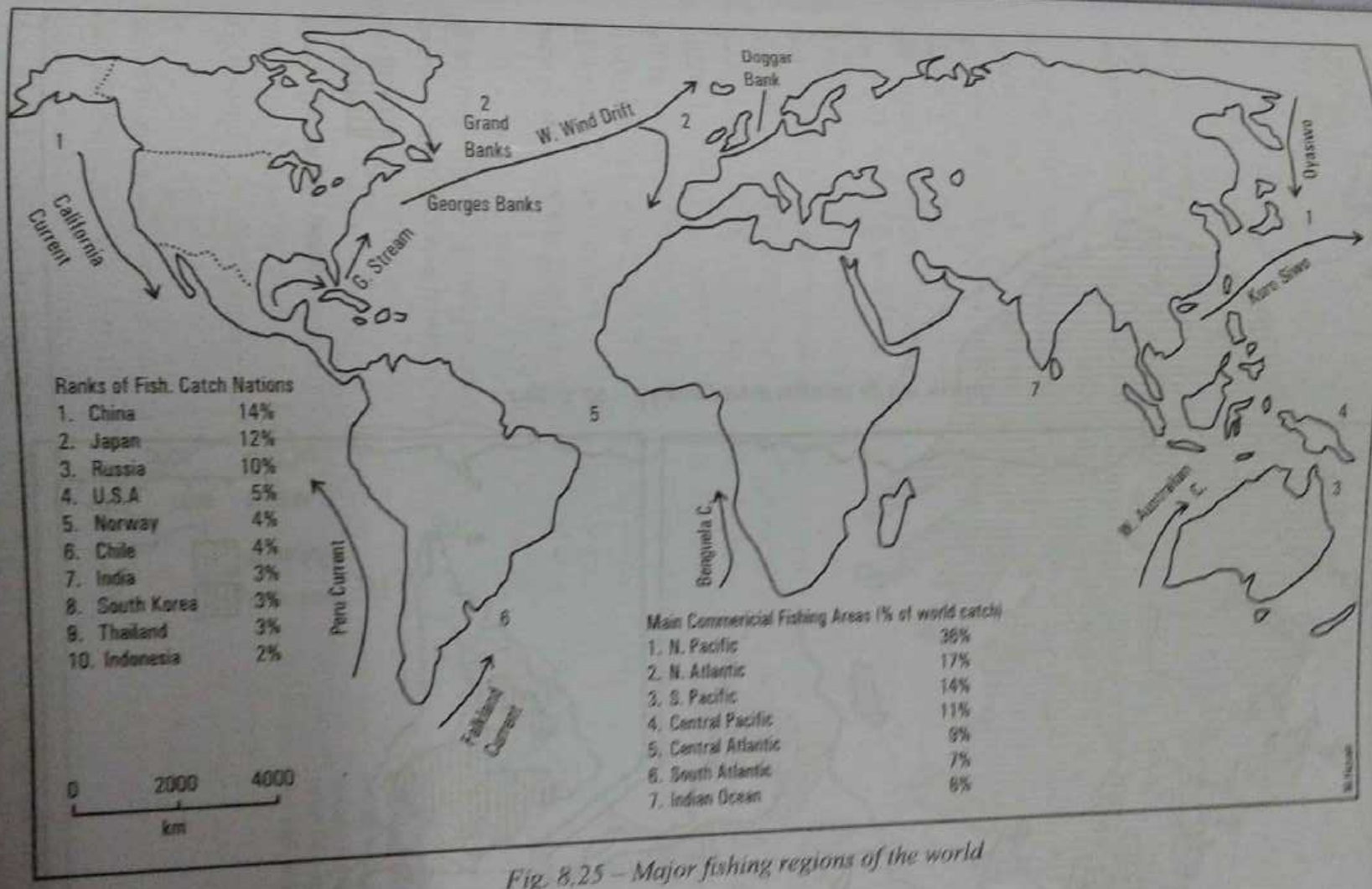


Fig. 8.25 – Major fishing regions of the world

Fig. 8.26 – Major forest regions of the world

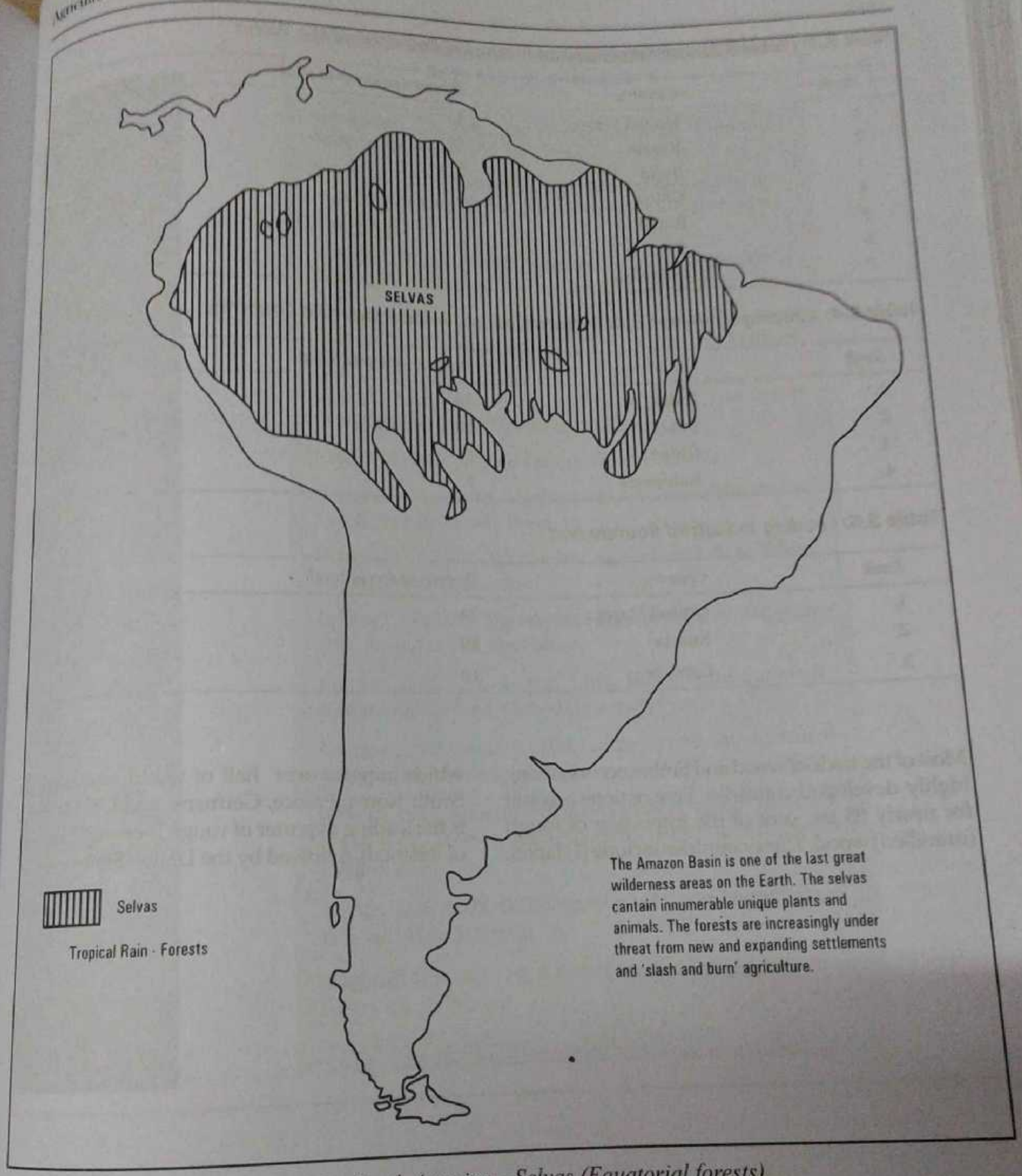

SELVAS
Selvas
Tropical Rain - Forests
The Amazon Basin is one of the last great wilderness areas on the Earth. The selvas cantain innumerable unique plants and animals. The forests are increasingly under threat from new and expanding settlements and 'slash and burn' agriculture.

Fig. 8.27 – South America – Selvas (Equatorial forests)

Table 8.3: (Table 8.3), Leading Logwood Producing Countries of the World

Rank	*Country*	*Percentage of world total*
1	United States	14
2	Russia	12
3	India	8
4	China	8
5	Brazil	7
6	Canada	5
7	Indonesia	4

Table 8.4: Leading Fuelwood and Industrial Roundwood Producing Countries

Rank	*Countries*	*Percent of World Total*
1.	India	13
2.	Brazil	10
3.	China	9
4.	Indonesia	7

Table 8.5: Leading Industrial Roundwood

Rank	*Country*	*Percent of world total*
1.	United States	24
2.	Russia	19
3.	Canada	10

Most of the trade of wood and timber occurs among highly developed countries. Five nations account for nearly 85 per cent of the importing of rough (unmilled) wood. These countries include (1) Japan, which imports over half of world total, and (2) South Korea, France, Germany and UK.Malaysia is the leading exporter of rough wood (35 per cent of the total), followed by the United States.

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CHAPTER NINE

Human Geography

Chapter Concepts

- First People (Major Tribes of the world)
- Indigenous People of Africa
- Indigenous People of Asia
- Indigenous People of Australia and New Zealand
- Indigenous People of Eurasia
- Indigenous People of North America
- Indigenous People of South America
- Population Patterns of the World

First People (Major Tribes of the World)

The major tribes of the world are called the first people or the indigenous people. Indigenous people are strikingly diverse in culture, religion, and social and economic organisations. Yet today, as in the past, they are falling prey to the outside world. By some they are idealised as the embodiment of spiritual values, by others they are denigrated as an obstacle impeding economic progress. But they are neither; they are the people who cherish their own distinct culture, are the victims of the past and present day colonialism, and are determined to survive. Some live according to their traditions, some receive welfare, others work in factories, offices or the professions. They maintain a close relationship with land and environment. There exists a co-operative attitude of give and take, a respect for the Earth and the life it supports, and the perception that humanity is but one of the many species. Some of the important indigenous people of the world have been plotted in Fig. 9.1

There are more than 250 million indigenous people in the world. As stated above, the indigenous people are the most disadvantaged groups of the society, suffering the worst health, receiving least education, and among the very poorest. The indigenous people have a strong sense of their own identity as unique people with their own lands, languages, and cultures. They are struggling to make both the ends meet. Now they are demanding that their lands be restored to them, that their cultures be protected and that their right to self determination be recognised. Since the western models of development, industrialisation and urbanisation becomes daily less sustainable, indigenous people may come to occupy a position of considerable influence. Their views on development and conservation could become central to decision making. As a consequence of the European expansion in the 1500 A.D. the Australian Aborigines, New Zealand's Maoris, North and South American Red-Indians, tribes of South East Asia, South Asia, and Siberia were killed, in large numbers, assimilated, or pushed into marginal lands.

Fig. 9.1 – Indigenous people of the world

Table 9.1: *Indigenous People of the World*

Continent /Country	Indigenous People
1. Africa	Afar, Babinga, Bantu, Berber, Bongo, Bobo, Bushman, Dinka, Efe, Fulani, Hottentot, Kikuyus, Lese, Mabuti, Masai, Nuer, Oromo, San, Shilluk, Tigmyon, Tswa, Tuareg, Twa, Zulu **(Fig. 9.1).**
2. Asia	Ainu, Asmat, Badawins, Chakma, Chin, Dani, Dayak, Hamang, Haren, Iban, Ifugao, Kachin, Kalinga, Karen, Kayan, Kedang, Kurds, Lisu, Marmo, Pakhtoons, Sakai, Semang, Shah, Vedda **(Fig. 9.2)**
3. Australia	Arunta, Bidjandjara, Dieri, Gurindji, Kadaku, Kamilaroi, Murngin, Tiwi, Wailbri **(Fig. 9.3)**
4. Europe/Russia	Chuckchi, Eskimo,Koryak, Lapps, Nemat, Somoyed, Tungus, Saami, Yakuts, Yukaghir **(Figs. 9.3 and 9.4)**
5. North America a. Canada	Bela, Blackfoot, Coola, Deni, Cree,Haida, Innu,Inuit, Metis, Tlinit **(Figs. 9.5 and 9.6).**
b. USA/Mexico	Apache, Arapaho, Chol, Comanachee, Crow, Dine, Hopi, Keres, Lacando, Maya, Navajo, Nez, Pawnee, Perce, Uti, Yucatec
6. South America	Achi, Akrori, Arawak, Aymara,Boro, Kareen, Kayapo,Lakona, Mapuchi Maskoy, Secoya, Toba.

Indigenous People of Africa

Afar

These ethnic communities are the dwellers of Ethiopia, Eritrea, Djibouti and Somalia. They are largely hunters and food gatherers and practice rudimentary agriculture, growing millets, maize and pulses.

Baka (Babinga/Bebyaka/Bebayaga/Bibaya)

This community of indigenous people are the inhabitants of south-eastern forests of Cameroon. The total number of this community is about 40,000. These people are hunters and food gatherers. They establish temporary camps of huts with twigs, branches and leaves. They hunt and trap in surrounding forests, using poisoned arrows. They sometimes obtain honey from the forests. Their religion is animist **(Fig. 9.1).**

Bantu

The Bantu ethnic groups are distributed from Cameroon east across Central and Eastern and Southern Africa. Their main concentration is in the eastern highlands of Africa (Tanzania, Kenya, Ethiopia).

Bemba

Bemba is a major community of Zambia. They live in villages of 100 to 200 people. Their total population is about 250,000. They practice primitive type of agriculture, hunting and gathering.

Berber

Pastoral communities of north-western Sahara (Algeria, Morocco, Tunisia). At present they have become settlers in oases growing wheat and dates. Berbers are essentially traders by profession.

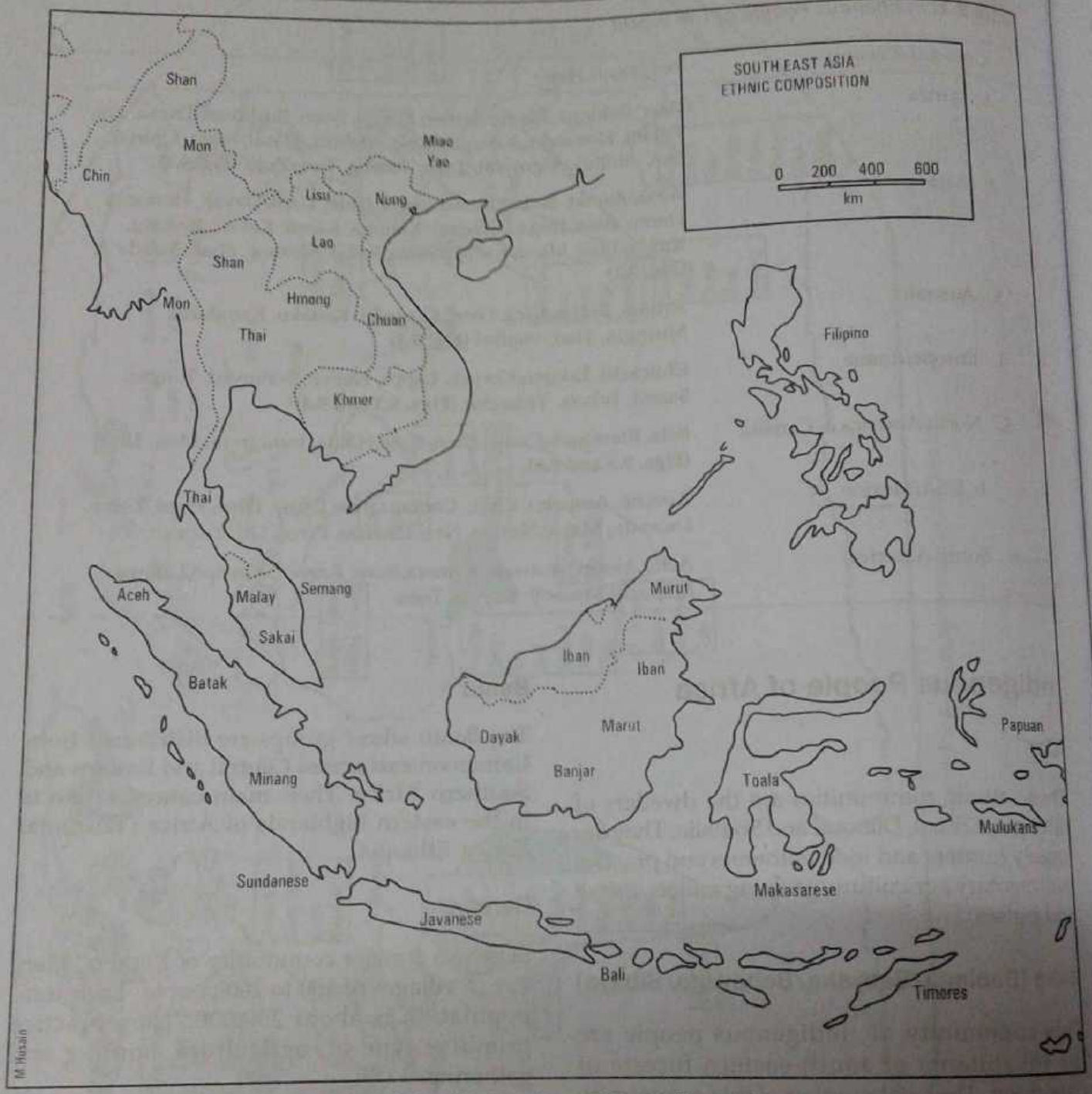


Fig. 9.2 – Major tribes of South East Asia

Bushmn (San)

Hunters and food gatherers of Kalahari Desert (Botswana and Namibia). Their total population is about 62,000. They hunt animals and gather plants over a vast area of the desert. Their way of life has provided liberty, leisure, and food security out of reach of the more 'advanced' areas of Africa. Their life has been considerably by Hottentots, Bantus and Europeans.

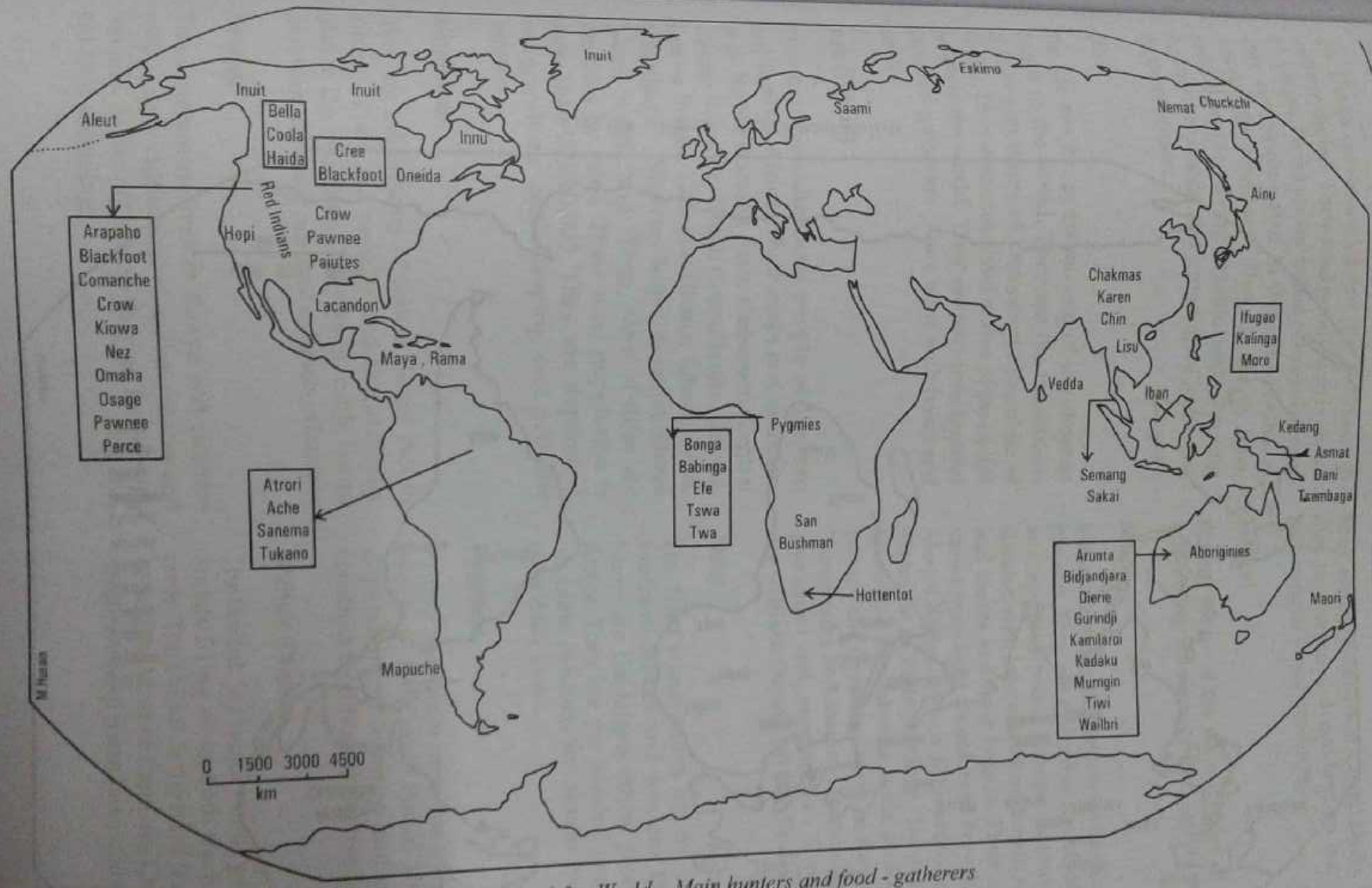


Fig. 9.3 – World – Main hunters and food - gatherers

Fig. 9.4 World Major pastoralism

Dinka

The Dinka communities are the dwellers of southern Sudan. Their total population is about 1.5 million. Dinka are the tallest people in Africa. They are concentrated in the Bahr-el-Ghazal region of the Nile-basin. They are mainly agro-pastoral people, relying on cattle herding during the summer season and growing millet during the rainy season.

Efe

The Efe are the pygmies, one of the shortest people in the world. They are the inhabitants of Ituri rain-forest of Democratic Republic of Congo. They are considered as one of the oldest people in the world. They are part-time hunters and food gatherers. They hunt with bows and arrows.

Fula (Fulani)

They are the indigenous people of Western and Central Africa. Their main concentration is in Benin, Burkina Faso, Cameroon, Central African Republic, Chad, Cote d'Ivoire, Guinea, Guinea Bissau, Gambia, Ghana, Liberia, Mali, Mauritania, Nigeria, Niger, Senegal, Sierra Leone, Sudan, and Togo. Most of them are Muslims by faith. Their total population is more than 27,000,000. They are dependent on agriculture cattle keeping, and nomadic herding.

Hottentots

They are inhabitants of Karoo Desert (South Africa). They are racially and linguistically akin to the Bushmen. They keep cattle herds. Moreover, the cattle are used as beasts of burden.

Kikuyus

This community lives in Kenya and practice rudimentary cultivation of millets, maize and legumes. In the off season they go for hunting and food gathering.

Lese

They are the dwellers of Congo Basin. Racially they are Negroes, dependent on hunting and gathering of forest products.

Mabuti

Mabuti is one of the communities of pygmies who are the dwellers of Ituri forests of Zaire.

Masai

Masai are the cattle herders on the East African plateau. They are a blend of the Mediterranean and negroid racial groups. Masais are tall, slender, with long small limb bones, narrow feet and hands and long fingers. Their skin colour varies from light chocolate to very dark brown. Mount Kenya, Mount Kilimanjaro and Mount Elgon lie in their territory. They are the best known of a number of cattle pastoralists who occupy the interior plateau of Kenya, northern Tanganyika and eastern Uganda. The clans are patrilineal and exogamous . Their main clans are (i) Black Ox and (ii) Red Bullock.

Nuer

The Nuer communities are the inhabitants of southern Sudan and western Ethiopia. The Nuers are the largest ethnic group of Eastern Africa. They are the pastoral people who rely on cattle products for almost every aspect of their daily lives.

Pygmies

Pygmy is a wider term for the short statured people of the Congo Basin. They are largely dependent on hunting and gathering and construct their huts at the tree tops.

Shilluk (Chollo)

The Shilluk is a major ethnic group of southern Sudan, living along both the banks of the Nile river. The Shilluk is the third largest community of Sudan. Most of them are Christians by faith, while some of them have converted to Islam.

Tswa (Batswa)

The Twa community belongs to the pygmy ethnic group. They are essentially hunters and food gatherers.

Tuareg

They are the nomadic pastoralists of the Sahara Desert. Tuareg move up into the desert to make use of the ephemeral grasses. Continuous movement allows vegetation to re-establish itself, and the water sources and grazing lands to replenish. Water and grazing rights are the shared heritage of the tribe or community **(Figs. 9.1 and 9.4)**.

Twa (Batwa)

Twa belongs to the pygmy ethnic group. They are nomadic hunters in the Congo Basin.

Yorubas (Boloki)

Yoruba is a dominant community of Benin and Nigeria, especially the Guinea-coast, west of the Niger-delta. They are typical west African negroes. Their total population is about two million. They are skilled cultivators, who grow mainly root crops, millet, maize, legumes, beans, peas, cassava, yams, and banana cultivation. Ibadan is the largest native city of the Yoruba.

Zulu

Zulu tribe lives in the Natal Province of South Africa. Having a population of about 11 million, it is the largest ethnic group of South Africa. Under apartheid, the homeland of KwaZulu (*Kwa* meaning place of) was created for Zulu people.

Indigenous People of Asia

Ainu (Aynu)

The indigenous people of Hokkaido are known as Ainu. They are also found in the Kuril Island of Russia. Their total population in Japan (Hokkaido) is about two lakh. In Japan, because of intermarriage over several decades with Japanese, the concept of '*Pure Ainu*' ethnic group is no longer feasible. More than half of the Ainu in Japan are believed to be illiterate. By faith they are the followers of animism, Buddhism and Russian Orthodox Christianity **(Fig. 9.1)**.

Badawins (Ruwala)

The term Badwain or *Baddus* has been derived from *el-Badia* (the occupants of deserts). Badwins are the camel keepers of the arid and semi-arid regions of South-West Asia. Camel, sheep and horses are the essential beasts of Badawins. Camel is the main source of wealth. They migrate from pasture to pasture in search of fodder and water. Their total population is about a million. They occupy the well defined tracts of coarse grasslands (*Hamad*) which afford permanent vegetation and water holes in oases. They enter the true sandy desert (*Nefud*) or rocky country (*Hana*) for short season in good years **(Figs. 9.1 and 9.4)**.

Chakmas (Changma)

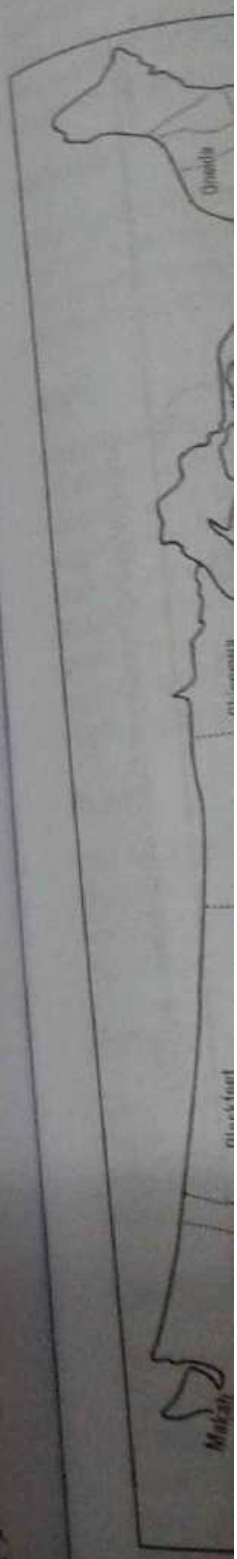
These are the indigenous people of Chittagong Hills of Bangladesh. The Chakmas are the largest ethnic group of the Chittagong Hills. Ethnically, the Chakmas are Tibeto-Burman, and are thus closely related to the tribes in the foothills of the Himalayas **(Fig. 9.1)**.

Chin

Chin is one of the ethnic groups of Myanmar. They are found mainly in the western parts of Myanmar. Their population in Myanmar is about 1.5 million. Some of them are living in Mizoram and Bangladesh. They belong to the Tibeto-Burman group **(Figs. 9.1 and 9.2)**.

Dayak (Dyak)

Dayaks are the indigenous people of Borneo. It is a loose term for over 200 riverine and hill dwelling ethnic subgroups, located mainly in



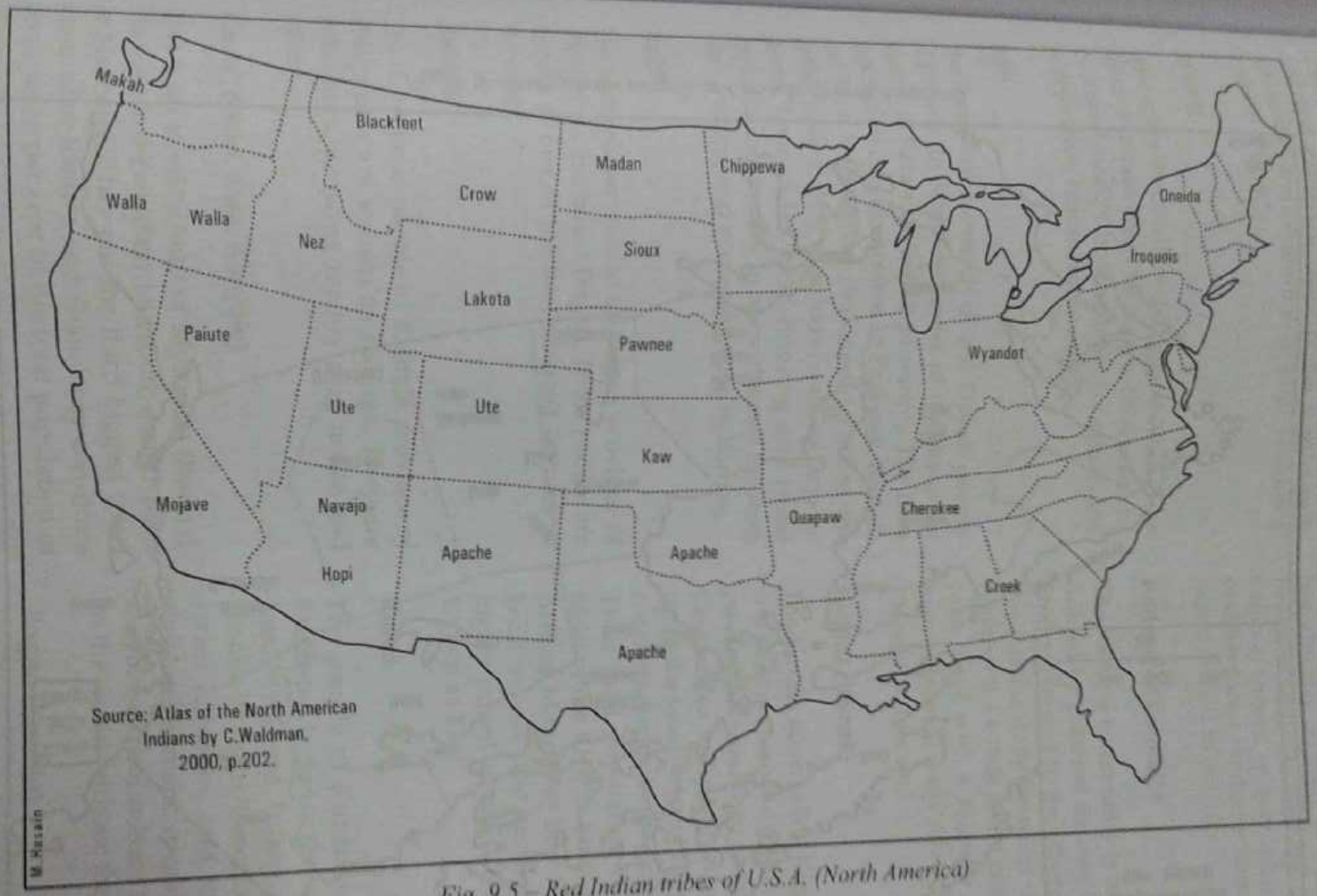


Fig. 9.5 – Red Indian tribes of U.S.A. (North America)

Fig. 8.6 — Indigenous people of Canada (North America)

the interior of Borneo. Most of them are hunters and food gatherers. Some of the youths gain recognition and admiration through becoming warriors (Fig. 9.2).

Hmong

Hmong are the dwellers of Thailand. They grow opium as a cash crop. Today the USA provides the largest market, but the import of opium and its derivative, heroin, is now illegal.

Iban

The Ibans are a branch of the Dayak people of Borneo. In Malaysia, most of the Ibans are located in Sarawak (Sabah province). The Iban population is concentrated in Sarawak, Brunei, and West Kalimantan (Indonesia). During the British period, they were known as Sea Dayaks. Ibans famous for head-hunting and tribal territorial expansion. In ancient times the Iban were a strong and successful tribe in Borneo.

Ifugao

The indigenous people of Ifugao province of Philippines are called Ifugao. These people are known as one of the best terraced farmers in the world.

Kalinga

The indigenous people of Kalinga province of Philippines are known as Kalinga. They are cultivators, growing mainly rice, maize and pulses.

Karen (Kayin, Kwa, Kanyaw)

This is an ethnic group of Myanmar (Burma). They live in the southern and south-eastern parts of Myanmar. They are the third biggest tribal group after Bamars and Shan. They constitute about seven per cent of the total population of Myanmar.

They practice shifting cultivation in the hilly regions of Thailand. Their economy is largely based on subsistence dry rice cultivation. Money has virtually no place in a Karen community. In case of failure of rice crop, they grow chili or bamboo shoots, or may collect and sell honey or other forest products. Nearly all the income raised is used to buy rice.

Kedang of Lembata

The Kedang community is made up of groups formed by paternal descent line. Each descent group is related to the others by marriage, and the relationships between these groups bind together the whole social fabric. Marriage must take place with a relative which includes a man's maternal uncle's daughter and a woman's paternal aunt's son.

Kirghiz (Kazak)

The Kazak, often called Kirghiz, are the largest and most numerous division of Turkish speaking pastoral nomads. They occupy territory between Caspian Sea to Tien-Shan mountain, and spread up to the headwater of Irtysh river. Their main concentration is in the Republic of Kyrgyzstan. Their total population is about one million. Most of the Kirghiz horses are the smaller and hardier Mongolian breed. They use *yak* as the beast animal. The horse is however, the most highly prized animal. The shelter of Kirghiz is known as *Yurt*.

Kurds

The people of Kurdistan are called Kurds. Kurdistan includes the northern parts of Iraq, Iran, Syria, and Turkey. Some of the Kurdish are also living in Armenia, Azerbaijan, Georgia, Israel Lebanon, and Russia. Linguistically they are Iranians speaking a form of Persian language. The Kurds are the largest ethnic group in the world without their own state.

Jingpo (Kachin)

These are the dwellers of Kachin Hills of Myanmar. They are also found in China, and

India (Arunachal Pradesh) along the border of Myanmar.

Pakhtoons

The indigenous people of Afghanistan. They are Aryans and their language is Pasto. These people belong to the Marshal race and have a long history of wars.

Sakai

Sakais are the indigenous people of Malaya who are found south of the Semang and usually at lower levels in densely forested valleys and plains. They construct rectangular huts with twigs, branches and leaves. For hunting, they use the blow-pipe and not the bow.

Semang

Small groups of Semang are found in the hill tracts of Malaya. Their general appearance is that of dwarfed negroes and, therefore, they are referred to as negritoes. Semangs still use bark cloth. They are dependent on hunting and wild products of the forests.

The hunting of the Semang is sporadic and confined to relatively small game. They depend mainly on vegetable food, hunting and fishing only when in need or opportunity arises.

Toala

The indigenous people of Sulawesi (Celebes) are known as Toala. The are hunters and food gatherers and ressemble to Negrito. They live in small family groups in relative isolation. They hunt with the bow and poisoned arrows. Their food supply is obtained mainly from plants insects and smaller games.

Vedda

The hill dwellers of central and southern Sri Lanka are known as Vedda. They are largely dependent of hunting, gathering and rudimentary agriculture.

Indigenous People of Australia and New Zealand

Arunta

Arunta are the indigenous people living in the desert of and scrublands of central Australia. They are the hunters and food gatherers. Their political institutions are markedly rudimentary **(Figs. 9.1 and 9.3)**.

Gurindji

Gurindji is a group of indigenous people living in Northern Australia in basin of Victoria River. Their land was handed back to them in 1975 by Prime Minister Gough Whitlam.

Tiwi

These are the indigenous people living in the Bathurst and Melville Islands in the vicinity of Darwin City. They colour their body with natural ochre pigments. They are essentially hunters and food gatherers. They hunt lizards, wallaby, carpet-snakes, buffalo, pig, foxes, turtle and seagull-eggs. They perform narrative dances to depict every day life or historical events. Newborn females are engaged to teem birth to men of at least 25 years of age although they do not start to live with them until the age of 14. All marriage contacts are arranged by the father of the female. A powerful and elderly man can have as many as 20 wives at the time or his death yet many of these could still be under the age of 14 meaning that they do not live with him.

Warlpiri

They are the dwellers of Warlpiri territory located in the Tanami Desert, Northern Territory (Australia). Their population is about 3000 to 4000. They are also living around the Alice Springs. They are famous for their tribal dances. A number of Warlpiri have toured England, Japan, Russia and USA to perform their dances.

Indigenous People of Eurasia

Eskimo

Eskimos are the dwellers of the tundra region of Siberia. They are largely dependent on seal and walrus hunting for their food. The most striking fact of Eskimo culture is the elaborate nature of their habitations, implements and weapons. For their winter stay, they construct ice-houses known as *igloo* **(Figs. 9.1 and 9.4)**.

Yukaghir

These are the indigenous people of Eastern Siberia (Russia). These reindeer hunters are living in the Verkhoyansk and Stanovoy mountains as well as along the southern tributaries of the Kolyma river. They are Mongoloid in race. They move and camp in small groups of families. Individuals rarely marry outside their group. Each band has its own hunting and fishing grounds to which it returns every year. For winter travel they use sledge drawn by domestic husky dogs. The 'old man' the oldest of the elders in every group, who presides at ceremonials and festivals, has considerable authority over its members **(Figs. 9.1 and 9.4)**.

Indigenous People of North America

Contemporary locations (or the location of significant number of descendents) by state or province of the indigenous people of North America is shown in **Fig. 9.1**. The important Red Indian tribes of North America have been described briefly in the following.

Arawak

They are the dwellers of Antilles and Bahama Islands of West Indies. It is believed that the first tribe encountered by Christopher Columbus, when he arrived on the island of Santa Maria de la Concepcion were the Arawaks **(Figs. 9.1 and 9.5)**.

Apache (Tineh,Tinde)

The Apaches are the indigenous people of South West U.S.A. Their territory stretches over Arizona, Colorado, New Mexico and Oklahoma **(Figs. 9.1 and 9.5)**. Some Apacheans have moved to large metropolitan areas. The largest Apache urban communities are living in Oklahoma, Kansas, Phoenix, Denver, San Diego and Los Angeles cities of USA.

Blackfoot (Blackfeet or Siksika)

The Blackfoot territory lay immediately east of the Rockies between the north and south branches of the Saskatchewan River, while some of them are living in the upper reaches of Missouri River **(Fig. 9.8)**. The Blackfoot people are one of the Red Indian hunting and gathering tribes. They are horse riders and buffalo hunters. They make large groups in summer for organised attack on the herds of buffaloes. The buffalo provides meat, hide, hair, sinew (thread), hooves and horns. The hides are used for shirts, leggings, tent, bags and receptacles of very kind. The shelter of the Blackfoot is known as *Tipi* (conical hut).

Bella (Coola, Haida, Tlingit)

The Bella and Coola are fishing people who inhabit the coastal areas of the Pacific Ocean from Alaska to Columbia and up to the Humboldt Bay in northern California. The coastal areas of the north Pacific are rich in marine life. These people are largely dependent on fish like cod, halibut, herring and salmon. During the later summer the females gather berries and roots. The villages of these fishermen are close to sea with ready access to fresh water and a landing beach **(Fig. 9.6)**.

Cree

The indigenous people of the sub-Arctic region of Canada around the James Bay and the Quebec Plateau are known as Cree. Their main concentration is in the states of Quebec, Ontario, Manitoba, Saskatchewan and Alberta **(Fig. 9.6)**. The total population of Cree is about two lakh.

They are dependent on hunting, fishing and food gathering.

Creek (Muskogee)

They are the dwellers of South East Culture Area, Central Georgia and Albama, Florida, Georgia Louisiana, Oklahoma, South Carolina, and Texas (Fig. 9.5).

Crow (Absaroka)

The indigenous people of North America living in the vallies of Yellowstone River and its tributaries are called Crow. They were pushed westward by the Europeans. They are essentially hunters and food gatherers (Fig. 9.5).

Hopi (Yuma)

Hopi are the flood farmers in the desert of Arizona of North America. They are sedentary cultivators. They live in compact villages called *pueblos*. They grow maize in the desert with the help of irrigation. The streams and springs draining from the high plateau provide water for their crops. Apart from maize, they grow melon, vegetables, squashes, beans, sunflowers, chili, onions, and cotton. They keep sheep and donkeys. The clans of Hopi are matrilineal. The agricultural land is normally held by women (Fig. 9.3).

Inuit (Eskimo, Innu, Inupiat, Inupiaq, Yupik)

Inuit are the dwellers of Arctic Culture, Alaska, Nunavut, Arctic Canada, Greenland and Siberia. Inuits are generally confined in the Arctic Tundra (treeless land). Inuits people are Mongoloid by race. An interesting feature of Inuit culture is its relative homogeneity across more than 8000 km. Their winter accommodations are known as Igloo (Fig. 9.6).

Metis (Bois, Brule)

People of mixed ancestry living in post-contact times mostly in Southern Manitoba and Saskatchewan, western Canada and Montana.

Navajo (Navaho, Dineh, Dine)

North-west Culture Area between Puerco and San Jose Rivers and San Juan River in northeastern Arizona, north-western New Mexico, Nevada, south-eastern Utah, and south-western Colorado (Fig. 9.5).

Paiutes (Paiute, Pahute)

Great Basin Culture Area. The Paiutes (Red Indians) are the hunters and gatherers of the Great Basin in western North America. Their main territory is between Columbia and Colorado rivers. They live in bands varying from few to about 100 persons.

During the winter the band congregate in one or two large semi-permanent settlements, but in summer season they broke up into family groups and move for hunting and gathering. Their winter house is known as Wikiup. The small animals, insects, and vegetables are the main food of the Paiute people. They also collect seeds of wild plants, berries, wild onion and clovers. The swarm of grasshoppers is considered as the occasion of great feast. They are governed by a headmen. The headman of individual communities inherit their position from their father (Fig.8.3).

Pawnee

They are the dwellers of Great Plains Culture Area. Pawnee's territory lies immediately east of the Rockies stretching over Kansas, Nebraska, and Oklahoma states (Fig.8.3).

Indigenous People of South America

Achi

Achi are the dwellers of Amazon Basin, living along the border of Brazil, Colombia and Peru. They have the essential characteristics of American Indians. In this region land and air are continually saturated. The main dependence is on agriculture. The main crops are beans, cassava, peppers, pineapples, pumpkin, root-crops, sweet potatoes, tubers and yam. They do not keep domestic animals (Fig. 9.1).

Aymara

The indigenous community of Aymara are the dwellers of coastal Peru. The are largely dependent on fishery. Their life style resembles to the Mapuche of Chile and Cola of Canada.

Boro

Boro are the dwellers of western Amazon along the border of Brazil, Peru and Columbia. They have the essential physical characters of American Indians (Red Indians). Their population is more than ten thousand. The Boro group does not live in scattered huts, but occupies a single large house, sixty to seventy feet long on each side and thirty or more feet high. The Boro have no domestic animals. They don't even keep dogs, although these are found among most Amazon people. Boro practice sedimentary agriculture, and grow beans, manioc, root crops, maize, peppers, pineapple, pumpkin, sweet-potatoes, tubers, and yams (Fig. 9.1).

Mapuche

The community of Mapuche lives along the coast of Chile. They are essentially fisherman who obtain their food from the rich marine life fish, seals, otter, whales, and shell-fish). The westerly winds and cyclonic storms of the 'Roaring Forties' result in cool temperature and very humid climate (Fig. 9.1).

Population Patterns of the World

Population

Earth is the home to more than 6.5 billion people. Its population continues to grow by about 80 million people per year. The distribution of population is, however, highly unequal. China has the largest population in the world, followed by India, USA and Indonesia, Brazil, Pakistan, Russia, Nigeria, Bangladesh and Japan.

Population Density

Population density is the average number of people living in a square kilometer of a country/region. The distribution of population of the world has been shown in Fig. 9.7, while the density of population has been given in Fig. 9.8. The world's population density is about 44 persons per sq km (114 persons per sq mile). There is an inverse relationship between prosperity and population.

Where people have access to quality healthcare and proper nutrition, they live longer. Moreover, when women are educated, employed, and expect that their children will survive childhood, they tend to have fewer children.

Natural Population Growth

Natural population growth is calculated by subtracting the total deaths from the total births in an area in a year. It does not include migration to or from the area. The world has a population growth rate of 1.1 per cent per annum.

Life Expectancy

Life expectancy is the average number of years a person is expected to live. It is based on the death rates of specific age groups in a given population.

Overpopulation

Overpopulation occurs when a population has outgrown an area's resources, such as land and water. Large parts of India, China, Indonesia, Pakistan, Bangladesh, and Nigeria are over-populated.

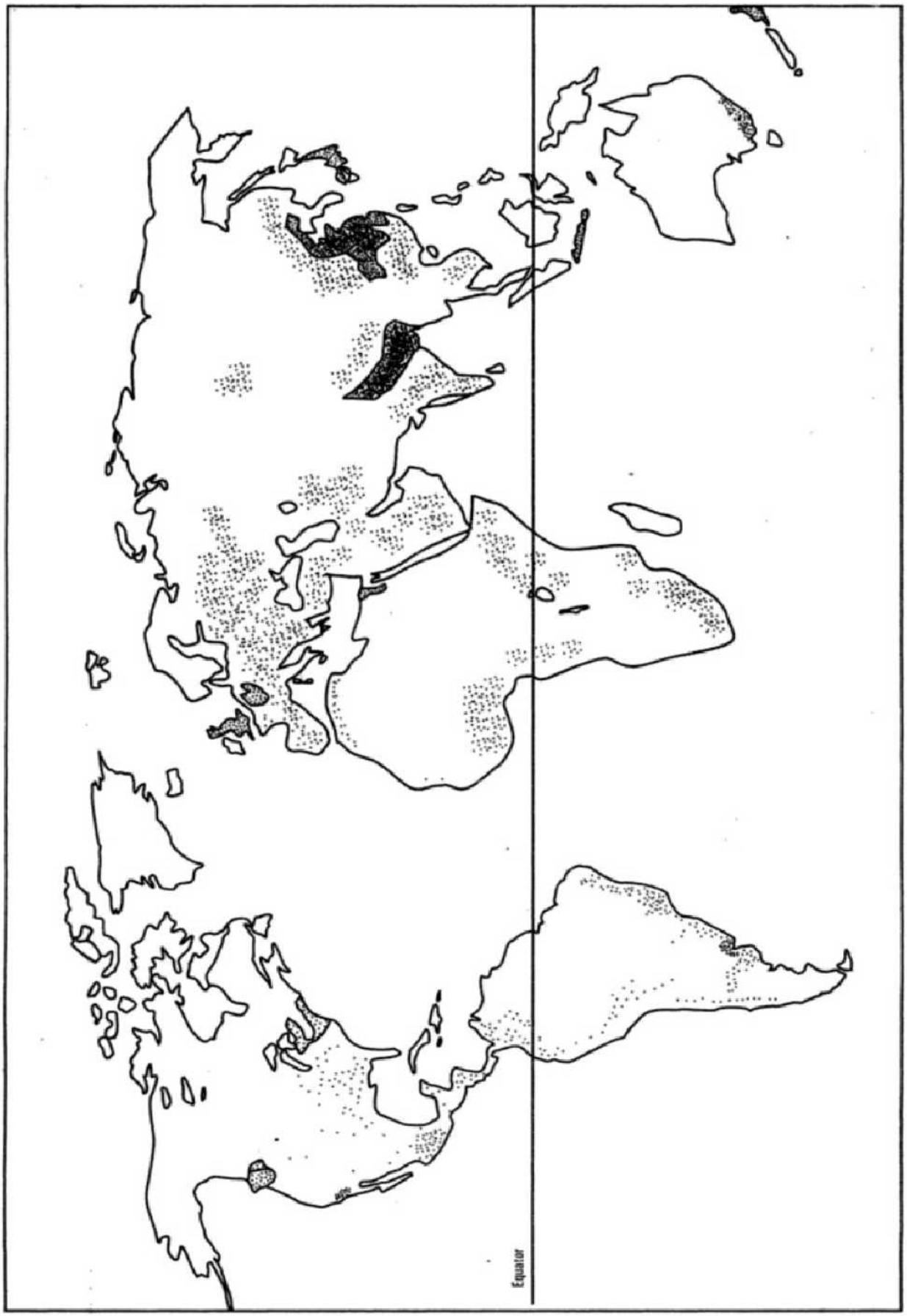


Fig. 9.7 – World distribution of population

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Missing Women

All over the world, whatever the level of their country's development, women are at a disadvantage. They are worse paid, if they are paid at all, than men for doing the same job and they are less represented in decision-making positions and processes. In some regions, just because of their gender, their very lives are at risk.

Women and girls are not as highly valued as men in many societies. United Nations (UN) estimates from 2006 say that between 113 and 200 million women are 'Missing". Every year between 1.5 and three million of them lose their lives as a result of gender-based violence or neglect. There are several explanations: in some countries (China and India are the example), boys are preferred to girls. This can lead to female infanticide or selective abortion. Those that survive may suffer the neglect of their parents, because food and healthcare are prioritised for the male members of the family.

In societies that value males more highly than females, the killing of women–'femicide'–is all too common; women's lives are considered cheap. But some femicide is dressed up as 'honour' killings. In countries where women are considered the property of men, their menfolk can murder them for choosing their own sexual partners (thereby supposedly besmirching family 'honour'). Young brides may be killed if their parents did not pay sufficient money to the husband – these are called *'dowry'* deaths. The international sex trade kills many women, as do wars. However, the main cause of women's death worldwide is domestic violence.

According to Jill Radford, femicide is the killing of women that is condoned or even promoted by states and/or a means of control over women as a sexual class and to maintain the patriarchal *status quo*. The absence and inadequacy of legal and policing institutions, and also their male profile, reinforces patriarchy. Radford claims that femicide, as seen in court and media, is surrounded by the myth of 'woman-blaming'.

Femicide is currently outlawed under the statute of the International Criminal Court. However, agreements and treaties remain to be ratified, both at the international and state levels, to enforce laws and guarantee on non-violence towards women.

***Table 9.2:** Gender Equity Index (GEI)-2006*

Country	*Gender Equity Index*
Sweden	89
Finland	86
Norway	86
Denmark	81
Australia	79
Canada	78
United States	78
United Kingdom	77
Israel	73
Brazil	68
France	64
Japan	61
China	58

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Fig. 9.8 – World – Density of population

Indonesia	52
Iran	48
Saudi Arabia	43
India	39
Pakistan	38
Chad	36
Yemen	26

Source: **The World Guide**, *2007,11th edition, New Internationalist Publications Ltd. pp.42-43.*

Migration

People have moved to new places throughout the history. Today, with the improvement in transportation, people can move farther and faster than ever before.

People often leave their homes in search of better economic, political or religious opportunities. These attractions to new homes are called *pull factors*.

Some people leave their old homes to escape natural disasters, persecution, or war. These are called *push factors*. People can move to new locations within their country (migration) or move to another country (immigration).

Cultural differences between immigrants and their new countries often lead to conflicts. Refugees are fleeing for their lives. Emigrants leave by their own choice. The difference is very important. Refugees are protected by international agreement and may be supported by the world community. Emigrants do not have these protections.

Cultural Diversity

Culture is the way of life of a given human society. Every society in the world has unique culture. Aspects of culture include a society's language, religion, art, customs, ethnicity, institutions, technology, and other traits. Countries can have multiple cultures, and cultures can cross national boundaries. Religion and language are the two distinguishing features of a culture. Thousands of religions are practiced and about 6000 languages are spoken in the world today.

Religions

Religion has been defined differently by different scholars. In the 18th century, Friedrich Schleirmacher defined religion as *'feeling of absolute dependence'* – absolute as contrasted to other, relative feelings of dependence. Otto defines the essence of religious awareness as awe, a unique blend of fear and fascination before the divine. The main characteristics of religious life are: (i) traditionalism, (ii) myth and symbol, (iii) concept of salvation, (iv) sacred places and objects, (v) sacred action, (vi) sacred writings, (vii) the sacred community (monastic order), and (viii) the sacred experience.

Religion like language, is a symbol of group identity and a cultural rallying point. All societies have value systems – common belief, understandings, expectations, and controls – that unite their members, and set them off from other different cultural groups. Such a value system is termed as a religion when it involves system of formal or informal worship and faith in the sacred and divine.

The non-religious values like Marxism also affect man and nature (environment) relationship. The Russian political ideologies (communism), for example, have a quasi-religious role. They have many of the elements of a religion, including a set of beliefs, ethical standards, revered leaders, an organisation and a body of literature akin to holy scripture. The main countries with concentration of different religions have been plotted in **Fig. 9.9**, while the number and ranks of adherents by country are given in **Table 9.3.**

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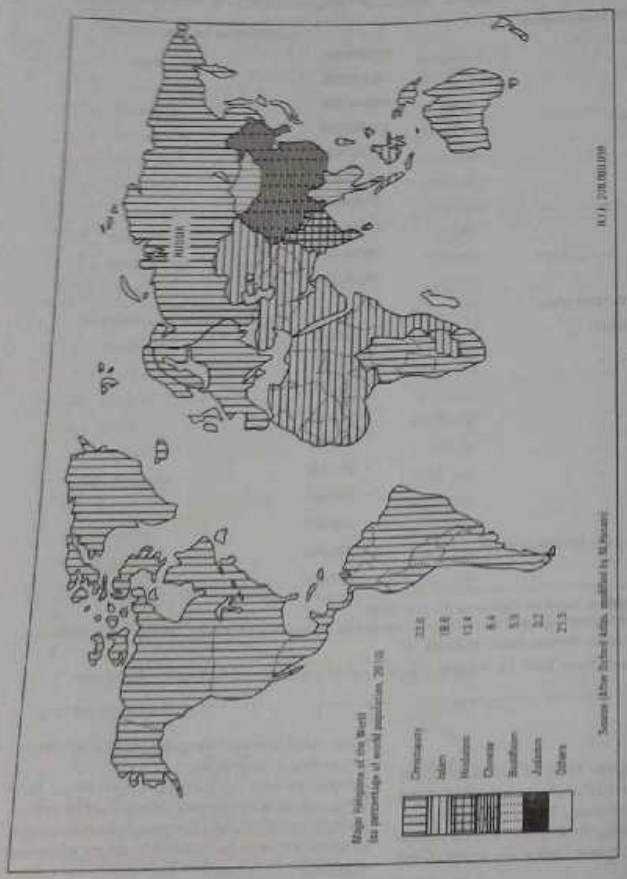

Fig. 9.9 – Major religions of the world

Table 9.4: *Main Groups of the Languages*

1. Afro-Asian	9. Malayo-Polynesian
2. American Indian	10. Mon-Khmer
3. Australian	11. Negro-Congo (Bantu)
4. Dravidian	12. Nilo-Saharan
5. Indo-European	13. Papuan
6. Inuktitut	14. Sino-Tibetan
7. Japanese and Korean	15. Uralic and Altaic
8. Khoisan	16. Unclassifiable

Source: **The Nystrom Desk Atlas** *2008, Herff Jones Education Division, Indianapolis, p.45.*

Indo-European Languages

Indo-European is the most widely spoken language family. About half the people in the world speak languages in this family, which originated in an area that extended from northern India to western Europe. The main groups and sub-groups of the Indo-European languages have been given in **Table 9.5**.

Table 9.5: *Indo-European Languages*

Indo-Iranian	**Indic**	
		Hindi
		Urdu
		Bangla (Bengali)
		Punjabi
	Iranian	Persian (Farsi and Dari)
		Pashtu, Tajik, Kurdish
Italic	**Latin or Romance**	Portuguese
		Spanish
		French
		Italian
		Romanian
Celtic	**Celtic**	Welsh Gaelic
Germanic	**West Germanic**	Dutch
		German
		English
	North Germanic	Icelandic
		Norwegian
		Swedish
		Danish
Balto-Slavic	**Baltic**	Lithuanian
		Latvian
	West Slavic	Polish
		Czech
	South Slavic	Slovenian
		Serbo-Croatian

	East Slavic	Macedonian Bulgarian Ukranian Belarussian Russian
Other Indo-European Languages	Other Indo-European Languages	Albanian Greek Armenian

Source: **The Nystrom Desk Atlas**, 2008, *Nystrom, Herff Jones Education Division*

Urbanisation

Nearly half of the world's population now lives in urban areas. The world's urban population has more than quadrupled in the past 50 years. As farming becomes more efficient, people move to cities in search of jobs. Nearly half of the world's population now live in urban areas.

The levels of urbanisation have been shown in **Fig. 9.10**. It may be seen from this figure that the developed countries are more urbanised in which 75 to 97 per cent of the total population is living in the urban areas. The level of urbanisation is below 25 per cent in the central African countries, while the level of urbanisation in most of the Asian countries (excepting Japan, South Korea, Hong Kong, Iran, Kuwait, Singapore, Saudi Arabia, Turkey, UAE) is between 25 and 50 per cent **(Fig. 9.10)**.

International Trade Organisation

Trade organisations are established by agreement between governments to increase free trade. NAFTA and EU are among the wealthiest and most influential trade organisations in the world. The major international trade organisations have been shown in **Fig. 9.11** and they are listed below:

APEC– Asia Pacific Economic Co-operation
AMU – Arab Maghreb Union
CAFTA-DR – Central American Free Trade Agreement – Dominican Republic
CEEAC – Economic Community of Central African States
EAC – East African Community
ECOWAS – Economic Community of West African States
EU – European Union
EURASEC – Eurasian Economic Community
GCC – Gulf Cooperation Council
MERCOSUR – Southern Common Market
NAFTA – North American Free Trade Agreement
SAARC– South Asian Association for Regional Cooperation
SACU – South African Customs Union

European Union

The European Union's single economy insures free trade as well as democracy and human rights, across much of Europe. Some members also share the same currency, the Euro. The countries of European Union are: Austria, Belgium, Bulgaria, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Ireland, Italy, Latvia, Lithuania, Malta, Netherlands, Poland, Portugal, Romania, Slovakia, Slovenia, Spain, Sweden, United Kingdom. The following are the candidate countries for the European Union: Croatia, Macedonia, Turkey **(Fig. 9.12)**.

World Money Markets

The financial world has traditionally been dominated by three major centres, Tokyo, New York and London, which house the headquarters of stock-exchanges, multinational corporations and international banks. Their geographic location means that at any one time in 24-hour

Fig. 9.10 : World urbanisation

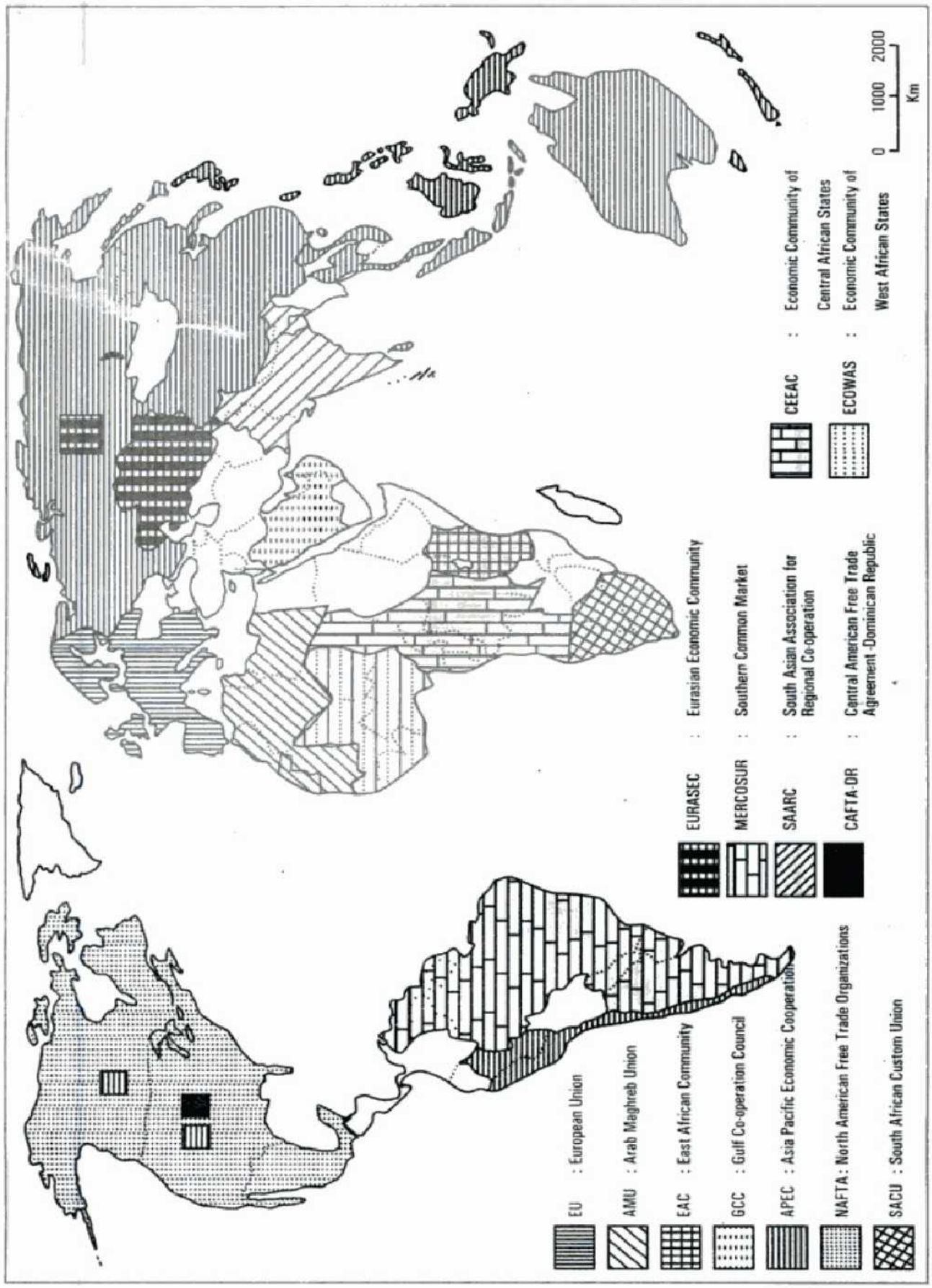
EU : European Union
AMU : Arab Maghreb Union
EAC : East African Community
GCC : Gulf Co-operation Council
APEC : Asia Pacific Economic Cooperation
NAFTA : North American Free Trade Organizations
SACU : South African Custom Union
EURASEC : Eurasian Economic Community
MERCOSUR : Southern Common Market
SAARC : South Asian Association for Regional Co-operation
CAFTA-DR : Central American Free Trade Agreement -Dominican Republic
CEEAC : Economic Community of Central African States
ECOWAS : Economic Community of West African States
0 1000 2000
Km

Fig. 9.11 – International Trade Organisation (After the Nystrom Desk Atlas, 2008, p.41.)

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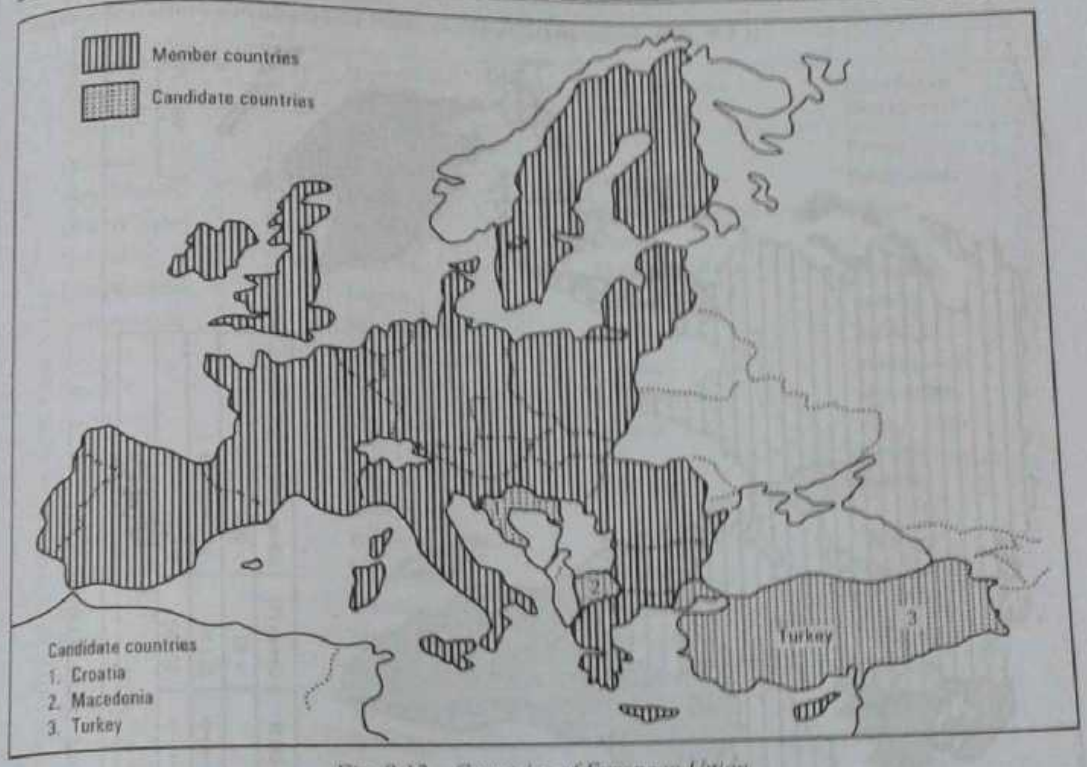

Fig. 9.12 – Countries of European Union

day, one major market is open for trading in shares, currencies, and commodities. Since the late 1980s, technological advances have enabled transactions between financial centres to occur at a ever-greater speed, and new markets have sprung up throughout the world.

Human Development Index

Human Development Index (HDI) was developed and applied for the first time in 1990. It is a device to measure a country's or region's achievements in the enhancement of human capabilities. The HDI is a composite of three components of human development: (i) longevity, (ii) knowledge (iii) standard of living, (iv) human poverty index, (v) gender development index, and (vi) gender empowerment index. Longevity is measured by life expectancy. Knowledge is measured by a combination of adult literacy (two-third weight). Standard of living is measured by purchasing power based on real GDP per capita as adjusted for local cost of living (purchasing power parity or PPP).

The highly developed and lowly developed countries have been shown in **Fig. 9.13**. The HDI of 2010 has been given in **Table 9.6**.

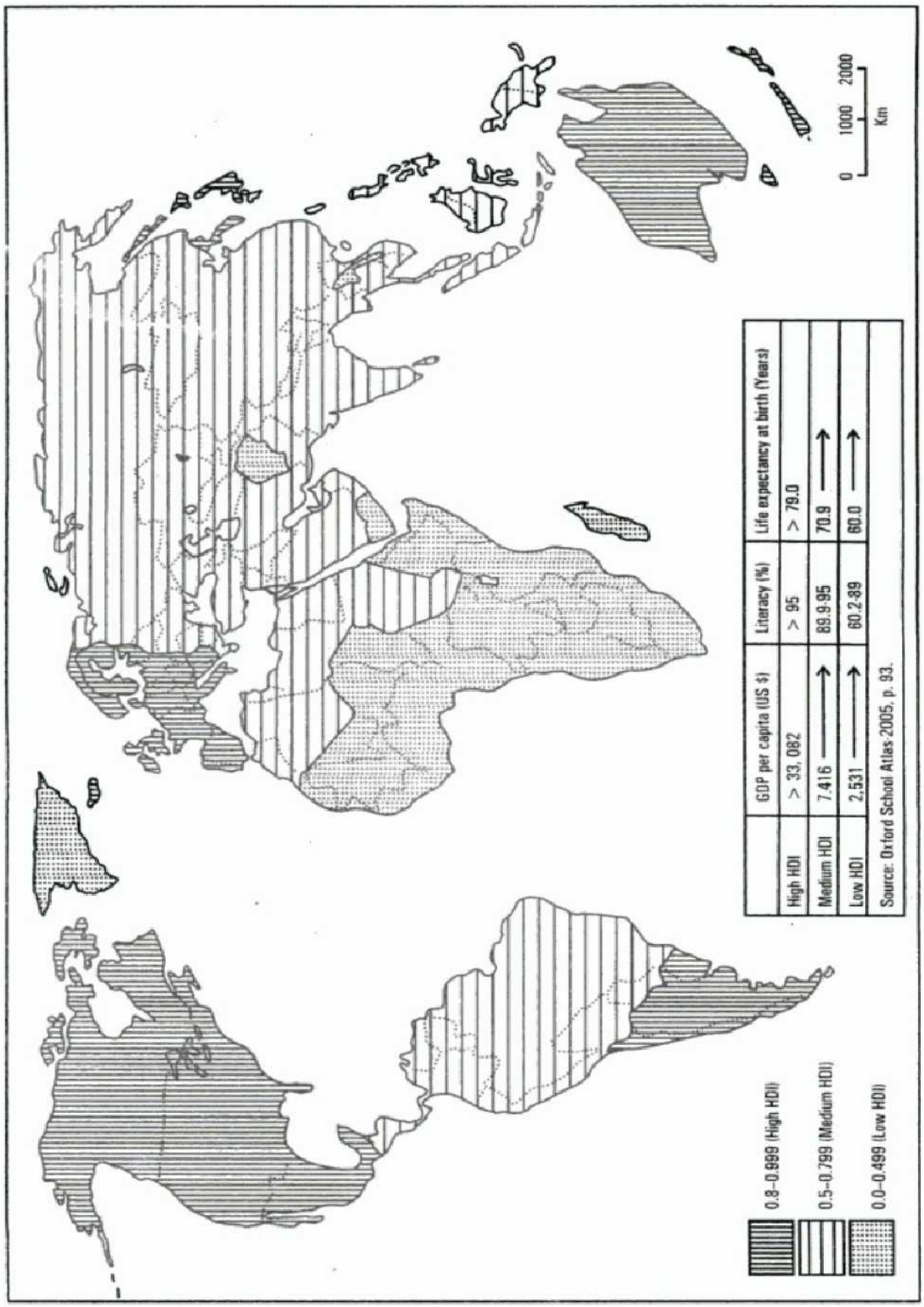
0.8–0.899 (High HDI)
0.5–0.799 (Medium HDI)
0.0–0.499 (Low HDI)
0 1000 2000
Km
GDP per capita (US $) | Literacy (%) | Life expectancy at birth (Years)
High HDI | > 33, 082 | > 95 | > 79.0
Medium HDI | 7.416 ⟶ | 89.9-95 | 70.9 ⟶
Low HDI | 2,531 ⟶ | 60.2-89 | 60.0 ⟶
Source: Oxford School Atlas 2005, p. 93.

Fig. 9.13 – World – Human Development

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Table 9.6:** Human Development Index (HDI)-2010 Ranking.* ***(Fig. 9.13)

Very High Human Development	*High Human Development*	*Medium Human Development*	*Low Human Development*
Norway	Bahamas	Fiji	Kenya
Australia	Lithuania	Turkmenistan	Bangladesh
New Zealand	Chile	Dominican Republic	Ghana
United States	Argentina	China	Cameroon
Ireland	Kuwait	El Salvador	Myanmar
Liechtenstein	Latvia	Sri Lanka	Yemen
Netherlands	Montenegro	Thailand	Benin
Canada	Romania	Gabon	Madagascar
Sweden	Croatia	Surinam	Mauritania
Germany	Uruguay	Bolivia	Papua New Guinea
Japan	Libyan Arab Jamahiriya	Praguay	Nepal
Korea (Republic of)	Panama	Philippines	Togo
Switzerland	Saudi Arabia	Botswana	Comoros
France	Mexico	Moldova	Lesotho
Israel	Malaysia	Mongolia	Nigeria
Finland	Bulgaria	Egypt	Uganda
Iceland	Trinidad and Tobago	Uzbekistan	Senegal
Belgium	Serbia	Micronesia	Haiti
Denmark	Belarus	Guyana	Angola
Spain	Costa Rica	Namibia	Djibouti
Hong Kong China(SAR)	Peru	Honduras	Tanzania (United Republic of)
Greece	Albania	Maldives	Cote d'Ivoire
Italy	Russian Federation	Indonesia	Zambia
Luxembourg	Kazakhstan	Kyrgyzstan	Gambia
Austria	Azerbaijan	South Africa	Rwanda
United Kingdom	Bosnia and Herzegovina	Syrian Arab Republic	Malawi
Singapore	Ukraine	Tajikistan	Sudan
Czech Rep.	Iran (Islamic Republic of)	Vietnam	Afghanistan
Slovania	Macedonia (former Yugoslavia)	Morocco	Guinea
Andorra	Mauritius	Nicaragua	Ethiopia
Slovakia	Brazil	Guatemala	Sierra Leone
United Arab Emirates	Georgia	Equatorial Guinea	Central African Republic
Malta	Venezuela	Cape Verde	Mali

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Estonia	Armenia	India	Burkina Faso
Cyprus	Ecuador	Timor-Leste	Liberia
Hungary	Belize	Swaziland	Chad
Brunei Darussalam	Colombia	Lao People's Democratic Republic	Guinea-Bissau
Qatar	Jamaica	Solomon Island	Mozambique
Bahrain	Tunisia	Cambodia	Burundi
Portugal	Jordan	Pakistan	Niger
Poland	Turkey	Congo	Congo (Democratic Republic of)
Barbados	Algereia	Sao Tome and Principe	Zimbabwe
-	Tonga	-	-
-	-	-	-

Note: The Human Development Ranking given in Table 9.6 were published in the Human Development Report, ***The Real Wealth of Nations: Pathways to Human Development****, United Nations Development Programme.*

It may be seen from the Table 9.6 that Norway has the first ranking in the world in Human Development Index, followed by Australia, New Zealand, USA and Ireland. The other countries which are included in the Very High Human Development in a descending order are Liechtenstein, Netherlands, Canada, Sweden, Germany, Japan, South Korea, Switzerland, France, Israel, Finland, Iceland, Belgium, Denmark, Spain, Hong Kong, Greece, Italy, Luxembourg, Austria, United Kingdom and Singapore.

China with a rank of 89 falls in the medium human development category. India has the *119th* in the medium human development category. The ranks of the other neighbouring countries are: Sri Lanka (91), Pakistan (125), Bangladesh (129) and Nepal (138).

In 2010, Zimbabwe has the lowest (169th) rank, while Congo Democratic Republic (168), Niger (167), Burundi (166), Mozambique (165) and Guinea-Bissau, Chad (163) are at the bottom of Low Human Development.

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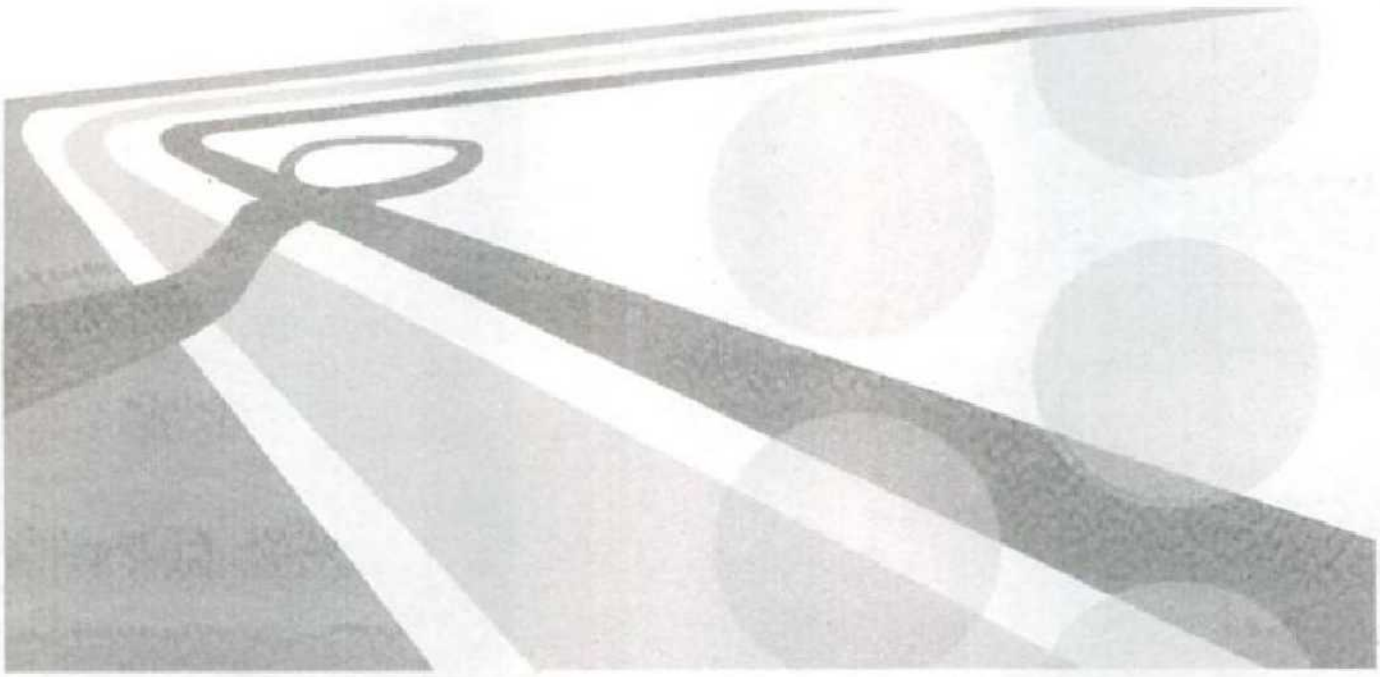

PART – II

INDIAN GEOGRAPHY

- India – Physical Setting
- Population
- Indian States

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Chapter Ten

India–Physical Setting

Chapter Concepts

- Size and Location
- Major Passes of India
- Natural Vegetation
- Water Resources of India
- Power Resources
- Iron and Steel Industry
- Drainage of India
- Monsoon
- Soils of India
- Natural Hazards
- Cotton Textile Industry
- National Highways

Size and Location

In area, India is the seventh largest country in area, and the second largest in population after China in the world. India is the cradle of human civilisation and the mother of history. India stretches from the snow-capped Himalayas in the north to sun drenched coastal villages of the south and the highly fertile valley of Brahmaputra in the east to the barren sandy desert in the west. It covers an area of 32,87,263 sq km. India extends between 8° 4′ and 37°6′ north and longitudes 68°7′ and 97°25′east. It extends 3,214 km from north to south and 2933 km from east to west. India has a frontier of about 15,000 km. The total length of the coastline of the mainland, Lakshadweep and Andaman and Nicobar Islands is 7,517 km. The states and union territories of India have been given in **Table 10.1**.

***Table 10.1**: States and Union Territories of India*

	State/Union Territory	*Capital*
1.	Andhra Pradesh	Hyderabad
2.	Arunachal Pradesh	Itanagar
3.	Assam	Dispur
4.	Bihar	Patna
5.	Chhattisgarh	Raipur
6.	Goa	Panaji
7.	Gujarat	Gandhinagar
8.	Haryana	Chandigarh
9.	Himachal Pradesh	Shimla
10.	Jammu & Kashmir	Srinagar (summer) & Jammu (winter)
11.	Jharkhand	Ranchi

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12.	Karnataka	Bangaluru (Bangalore)
13.	Kerala	Thiruvananthapuram
14.	Madhya Pradesh	Bhopal
15.	Maharashtra	Mumbai
16.	Manipur	Imphal
17.	Meghalaya	Shillong
18.	Mizoram	Aizawl
19.	Nagaland	Kohima
20.	Odisha (Orissa)	Bhubaneshwar
21.	Punjab	Chandigarh
22.	Rajasthan	Jaipur
23.	Sikkim	Gangtok
24.	Tamil Nadu	Chennai
25.	Tripura	Agartala
26.	Uttar Pradesh	Lucknow
27.	Uttarakhand	Dehra Dun
27.	West Bengal	Kolkata

Union Territories

Andaman & Nicobar	Port Blair
Chandigarh	Chandigarh
Dadar & Nagar Haveli	Silvassa
Daman & Diu	Daman
Delhi, NCR	New Delhi
Lakshadweep	Kavaratti
Puducherry	Puducherry

India has common border with Afghanistan, Pakistan, China, Nepal, Bhutan, Myanmar, and Bangladesh. Sri Lanka is separated from India by a narrow channel of sea known as the Palk Strait and Gulf of Mannar. The length of international boundaries of India with the adjacent countries has been given in **Table 10.2.**

***Table 10.2**: Border of India with Neighbouring Countries*

	Country	*Length km*	*Percentage of total length of border*
1.	Bangladesh	4096	26.95
2.	China	3917	25.99
3.	Pakistan	3310	21.78
4.	Nepal	1752	11.53
5.	Myanmar	1458	9.89
6.	Bhutan	587	3.86
7.	Afghanistan	80	0.52

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Border of Indian States with Neighbouring Countries

1. Afghanistan: Jammu and Kashmir.
2. Bangladesh: Assam, Meghalaya, Mizoram, Tripura, and West Bengal.
3. Bhutan: Arunachal Pradesh, Assam, Sikkim, and West Bengal.
4. China: Arunachal Pradesh, Himachal Pradesh, Jammu and Kashmir, Sikkim and Uttarakhand.
5. Myanmar: Arunachal Pradesh, Manipur, Mizoram, and Nagaland.
6. Nepal: Bihar, Sikkim, Uttarakhand, Uttar Pradesh, and West Bengal.
7. Pakistan: Gujarat, Jammu and Kashmir, Punjab, and Rajasthan.

India: Geographical Extremes

Hottest Place: Briawali, Bikaner District, 56°C, 5th June, 1991.

Coldest Place: Dras in Ladakh (Jammu & Kashmir), - 45°C on 28th December, 1910.

Wettest Place: Mawsynram (Meghalaya) average annual rainfall about 11,875 m.

Highest Peak: K^2 (5611m) Jammu & Kashmir.

Longest River: Ganga River, 2510 km, catchment area 861,400 sq km.

Largest River Island: Majuli, Brahmaputra River (Assam), area about 1500 sq. km.

Largest Desert: Thar Desert, area 259,000 sq.km.

Largest Plateau: Deccan Plateau, 100,000 sq. km.

Highest Waterfall: Jog Falls on Sharavati River (Karnataka), height 253 m.

Longest Coastline: Gujarat, 1600 km.

Longest Beach: Marina Beach-Chennai, 13 km. It is one of the longest sea beaches in the world.

Largest Brakish Water Lake: Chilka Lake (Odisha, area 916 sq km.).

Longest Tunnel: Kharbude Tunnel (6.45 km). It connects Mumbai with Goa.

Longest Canal: Indira Gandhi Canal, 682 km in length.

Highest Dam: Bhakra Dam on Satluj River (Punjab), 226 m.

States of India lying exclusively in the Himalayas: Arunachal Pradesh, Himachal Pradesh and Sikkim.

States lying partly in Himalayas and partly in plains: Assam, Jammu and Kashmir, and Uttrakhand.

Boundary between India and Pakistan is known as Red Cliff Line.

Boundary Line between Pakistan and Afghanistan: Durand Line.

The Islands of Andaman and Nicobar are separated by Ten Degree Channel.

The Great Channel lies between Little Andaman and South Andaman.

***Table 10.3**: States with Longest Coastline*

	State/Union Territory	*Length of coastline (km)*
1.	Andaman and Nicobar	1962
2.	Gujarat	1215
3.	Andhra Pradesh	907
4.	Tamil Nadu	974
4.	Maharashtra	653

Physiographic Divisions of India: On the basis of physiography, India is divided into the following divisions:

1. The Himalayan Mountains.
2. The Great Plains of India.
3. The Peninsular Plateau.
4. The Coastal Plains.
5. The Islands.

The Himalayas (Himadari): The Himalayas are one of the youngest, loftiest and mightiest mountains in the world. They are about 2400 km from the Indus Gorge in the west to the

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Brahmaputra Gorge in the east. Their width varies from about 500 km in Jammu and Kashmir to about 200 km in Arunachal Pradesh. The southern boundary of the Himalayas is formed by the foothills of Shiwaliks (300 m contour), but the northern boundary is obscure and merges with the Tibet Plateau (Fig. 10.1).

The highest peaks of the Himalayas have been shown in **Fig. 10.2**. In Himalayas, the number of peaks higher than 8000 m is 21, and those over 7500 m are 40. Most of the main ranges fall in India, Nepal, Bhutan and along the southern border of Tibet. The first ten highest peaks of the Himalayas are shown in **Fig. 10.2** and their heights are given in **Table 10.4**.

***Table 10.4:** Highest Peaks of Himalayas*

Peak	*Nepali Name*	*Chinese Name*	*Height above the Sea Level (M)*
1. Mt. Everest	Sagarmatha	Gomolangma	8848
2. K^2 (Karakoram)	-	-	8611
3. Kanchenjunga	Kangchenjanga	-	8598
4. Lhotse	Lhotse	Lhotse	8516
5. Makalu	Makalu	Makalu Shan	8463
6. Cho Oyu	Cho Oyu	Qowowuyag	8201
7. Dhaulagiri	Dhawalagiri	-	8167
8. Manaslu	Manaslu	-	8163
9. Nanga Parbat	-	-	8126
10. Annapurna	-	-	8091

The Great Himalayas are classified into four parallel longitudinal zones which have distinguished orographical and geological features as follows:

(1) Tethys/Tibetan or Trans-Himalayas including Karkoram, Ladakh and Zaskar (Zanskar) Ranges.

(2) Inner / Higher or Greater Himalayas.

(3) Lesser or Lower Himalayas.

(4) Outer Himalayas/Sub-Himalayas or Shiwaliks.

1. **The Tethys or Tibetan Himalayas**: It is about 40 km wide and lies just north of the Higher Himalayas. Its altitude varies between 3000 m and 4300 m. It is made up of highly fossiliferous rocks ranging in age from the earliest Paleozoic (Cambrian) to Tertiary (Eocene). It is separated from the Eurasian Plate by the Indus-Tsangpo Suture Zone.

2. **The Inner/ Higher or Greater Himalayas**: It forms the northern-most line of high ranges, over 6000 m in altitude, covered with perpetual snows and contains several of the highest peaks of the world. Formed mainly of the Central Crystalline (granites and gneisses) rocks, it is about 50 km wide.

3. **The Lesser or Lower Himalayas**: The Lower Himalayas consist of middle ranges and is closely related to the Inner Himalayas. It has an intricate system of ranges which are some 60 to 80 km wide. The important ranges of Lesser Himalayas include Pir-Punjal and Dhauladhar, stretching in Jammu and Kashmir and Himachal Pradesh. This zone is composed mainly of unfossiliferous formations.

4. **The Outer or Sub-Himalayan Zone**: It is separated from the Lesser Himalays at

Fig. 10.1 – Mountain ranges

some places by flat-bottomed valleys. It is represented by the autochthonous foothills of the Shiwalik ranges which are made up entirely of folded, poorly fossiliferous sediments of the Tertiary Age. The Shiwalik range makes almost a continuous chain of more than 2400 km from the Indus gorge in the northwest to the Brahmaputra in Assam. Having a width of 10 to 50 km, the height of Shiwaliks seldom exceeds 1300 m. The

The Himalayas have great geo-climatic, socio-economic and cultural significance for the people of India. Their significance may be summarised as under:

1. **Climatic Influence**: The Himalayas influence the climate of India significantly they intercept the summer monsoon, coming from the Arabian Sea and the Bay of Bengal, and protect the Great Plains of India from the Siberian cold winds in winters.
2. **Defence**: The Himalayas protected India from the outside invaders. In fact, India has never been attacked from the northern side.
3. **Source of Perennial Rivers**: Most of the mighty and perennial rivers of India originate from the Himalayan glaciers.
4. **Fertile Soils**: The great rivers of India deposit fertile soils in the Great Plains of India, making them one of the most productive plains of the world.
5. **Forest Wealth**: The Himalayas are very rich in forest and pharmaceutical herbs. They provide fuelwood, timber, edibles, fodder, medicinal herbs and raw materials for industries.
6. **Hydro-electricity**: The Himalayas offer numerous sites for the generation of hydroelectricity. Dulhasti, Baghliar, Silal (Chenab), Pong, Dehra on Beas, Bhakra-Nangal, Giri-Bata, Bassi, Chamera, Nathpa-Jhakri on Satluj, Tehri, Koteshwar, Palra (Bhagirathi), etc. are some of the important hydel projects in the Himalayas.
7. **Minerals**: The Himalayas are rich in metallic and non-metallic minerals. Coal is found in Kashmir, copper, lead, zinc, nickel, cobalt, tungsten, gold, silver, limestone, precious and semi-precious stones, gypsum, magnesite, marble and building materials, etc. are the other minerals found in the states of Uttarakhand, Himachal Pradesh, Jammu and Kashmir, Sikkim and Arunachal Pradesh.
8. **Tourism**: There are numerous hill stations in the Himalayas which attract thousands of international and domestic tourists throughout the year. Some of the important tourist stations in the Himalayas are Gulmarg, Sonmarg, Pahalgam, Yushmarg, Srinagar, Dalhousie, Dharamshala, Chamba, Shimla, Kullu, Manali, Mussoorie, Nainital, Ranikhet, Bageshwar, Almora, Darjeeling, Gangtok and Itanagar.
9. **Holy Places**: There are numerous religious and sacred places in the Himalayas which are visited by the people. A large number of pilgrims visit the sacred shrines of Amarnath, Badrinath, Gangotri, Kedarnath, Jwalaji, Uttarkashi, Vaishno Devi, Yamnotri, etc.
10. **Alpine Pastures**: The alpine pastures at high altitude provide nutritious fodder to the sheep, goats, and yaks of the tribal people of the Himalayas.
11. Himalayas are the abode of rich cultural heritage of tribes.

Mountain Ranges and High.est Peaks of India

The highest peak in India: K^2 (Godwin Austin) – 8611 m **(Fig. 10.2)**.

The highest peak in Aravallis: Guru Shikhar (Mt. Abu) – 1722 m **(Fig. 10.3)**.

The highest peak in Satpura: Dhupgarh (Mahadeo Hills) – 1350 m **(Fig. 10.3)**.

The highest peak in Eastern Ghats: Dewodi = Munda (Odisha) – 1598 m **(Fig. 10.3)**.

The highest peak in Western Ghats and the highest peak in the Peninsular India: Anaimudi (Annamalai Hills – Kerala) – 2695 m **(Fig. 10.3)**.

The highest peak in Nilgiri (Tamil Nadu – Kerala border): Doda Betta – 2636 m **(Fig. 10.3)**.

The highest peak in Andaman and Nicobar: Saddle Peak – 737 m **(Fig. 10.3)**.

The highest peak in Arunachal Pradesh: Kangto – 7090 m (near Tibet Border)

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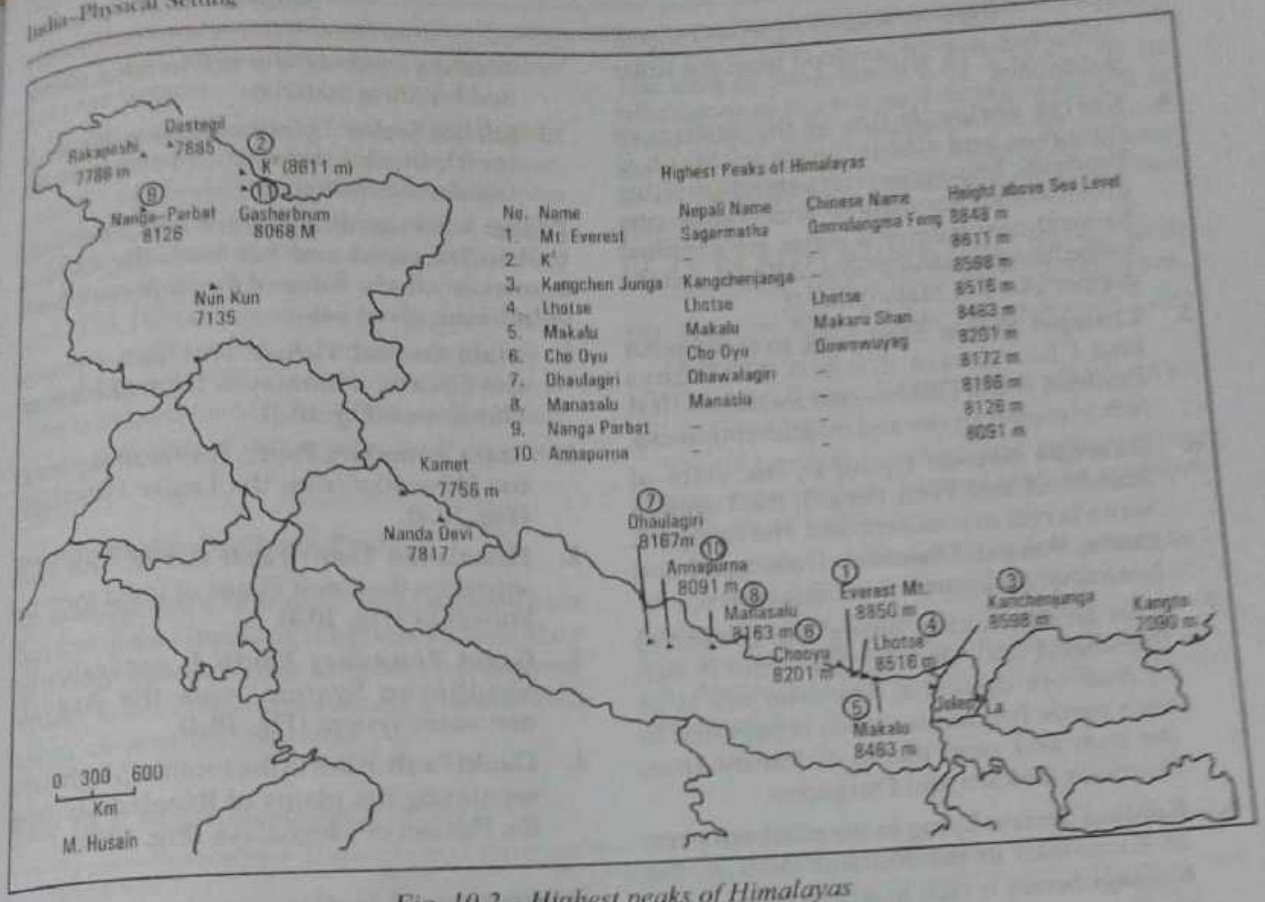
Highest Peaks of Himalayas
No. Name Nepali Name Chinese Name Height above Sea Level
1. Mt. Everest Sagarmatha Qomolangma Feng 8848 m
2. K' – – 8611 m
3. Kangchen Junga Kangchenjanga – 8598 m
4. Lhotse Lhotse Lhotse 8516 m
5. Makalu Makalu Makaru Shan 8463 m
6. Cho Oyu Cho Oyu Qowowuyag 8201 m
7. Dhaulagiri Dhawalagiri – 8172 m
8. Manasalu Manaslu – 8156 m
9. Nanga Parbat – – 8126 m
10. Annapurna – – 8091 m
Rakaposhi 7788 m
Distegil 7885
K (8611 m)
Nanga-Parbat 8126
Gasherbrum 8068 M
Nun Kun 7135
Kamet 7756 m
Nanda Devi 7817
Dhaulagiri 8167m
Annapurna 8091 m
Manasalu 8163 m
Everest Mt. 8850 m
Lhotse 8516 m
Chooyu 8201 m
Kanchenjunga 8598 m
Kangto 7090 m
Jelep La
Makalu 8463 m
0 300 600
Km
M. Husain

Fig. 10.2 – Highest peaks of Himalayas

The highest peak in Gujarat: Sarkala (Gir Hills) – 643 m **(Fig. 10.3)**.

The highest peak in Jharkhand: Parasnath – 1366 m **(Fig. 10.3)**.

The highest peak in Maharashtra: Kalsubai – 1646 m near Igatpur **(Fig. 10.3)**.

The highest peak in Mizoram: Blue Mountain – 2157 m **(Fig. 10.3)**.

The highest peak in Nagaland: Saramati Peak – 3826 m **(Fig. 10.3)**.

The highest peak in West Bengal: Tiger Hill – 2590 m **(Fig. 10.3)**.

The highest peak in Uttarakhand : Nanda Devi – 7817 m **(Fig. 10.3)**.

Series and Faults

Series is a structure of rock system. In a rock system there may be several series. Some of the economically important series and faults have been shown in **Fig. 10.4.** Their main characteristics have been described briefly in the following:

1. **Bijwar Series:** It is apart of the Vindhyam System. Rich in red sandstone, the Bijwar Series is known for diamonds and precious stones.
2. **Champaner Series:** It lies outside the Aravallis in the vicinity of Vadodra. It is known for conglomerates, marble and slate. An attractive variety of green marble is found in this series.
3. **Champion Series:** Lying in the state of Karnataka to the south-east of Banglore, this series belongs to the Dharwar System. Rich in gold, the Kolar goldmines lie in this series. The gold content in this series is about 5.5 grams per tone of ore. About 60 per cent

per cent of the Indian gold is mined from the Kolar goldmines.

4. **Chilpi Series**: It lies in the district of Balaghat and Chhindwara of Madhya Pradesh. The series consists of phyllite, green-stone, manganese and copper ore. Mineral ores from this series are supplied to the iron and steel plants of Bhilai and the copper plant of Malanjkhand.
5. **Closepet Series**: Stretching over Balaghat and Chhindwara districts of Madhya Pradesh, it is a Dharwarian formation. It is rich in copper pyrite and magniferous rocks.
6. **Damuda Series:** Lying in the state of Jharkhand and West Bengal, the Damuda Series is rich in coal deposits. The Raniganj, Jharia, Bokaro, Dhanbad, Daltenganj and Karanpur coal mines lie in this series.
7. **Iron Series**: Lying along the border of Jharkhand and Odisha, this series is rich in iron ore deposits. The iron ore is of high grade haematite which is supplied to the iron and steel plants of Jamshedpur, Rourkela, Bokaro and Durgapur.
8. **Kaldagi Series**: Lying in the northern parts of Karnataka in the Raichur District, the Kaldagi Series is rich in gold and precious stones.
9. **Khondolite Series:** It occupies a large area in the Eastern Ghats from the northern extremity to the valley of Krishna. It is famous for charnokite stones and gneisses.
10. **Panchet Series**: Lies on the border of Jharkhand and West Bengal. It is rich in coal and metallic minerals.
10. **Rialo Series:** Also known as Delhi Series, it extends from Delhi (Majnu-Ka-Tila) to Alwar. The famous Makrana marble is obtained from this series.
11. **Sakoli Series**: Stretching over Jabalpur and Rewa Districts, this series belongs to the Dharwar System. It is rich in mica, dolomite, schist and marble.
12. **Sausar Series**: This series stretches over Nagpur and Bhandara districts of Maharashtra and Chhindwara District of Madhya Pradesh. It is rich in mica, marble and building materials.
13. **Talcher Series**: Lying in Odisha, this series is rich in coal deposits. It belongs to the Gondwana formation.

Faults: A surface along which a rock body has broken/fractured and has been displaced is known as a fault. Some of the important faults of India are given below:

1. **Main Central Thrust**: This fault separates the Greater Himalayas from the Lesser Himalayas **(Fig. 10.4).**
2. **Main Boundary Fault**: This fault separates the Shiwaliks from the Lesser Himalayas **(Fig. 10.4).**
2. **Himalayan Front Fault (HFF):** This fault separates the Great Plains of India from the Shiwaliks **(Fig. 10.4)**.
3. **Great Boundary Fault**: It separates the Vindhayan System from the Aravalli mountain system **(Fig. 10.4)**.
4. **Dauki Fault**: It lies to the south of Meghalaya, separating the plains of Bangladesh from the Plateau of Meghalaya **(Fig. 10.4).**

Drainage of India

Drainage may refer either to natural drainage of the land-surface or to the system of land-drainage introduced by human activity. Natural drainage of the land-surface is organised in drainage basins. Drainage basins are those areas in which water is concentrated and flows into the drainage network. The drainage system of India may be divided into the Peninsular Drainage, and the Extra-Peninsular Drainage or the Himalayan Drainage System.

The Himalayan Drainage System or the Extra-Peninsular Drainage

The Himalayan drainage system comprises all the international rivers of India, i.e. the Indus, the Ganga, and the Brahmaputra. Most of these rivers and their major tributaries are perennial in character, obtaining their water from the glaciers, springs and rains. These rivers are in

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their youthful stage carving out a number of erosional landforms like waterfalls, cataracts, rapids, gorges, steepsided valleys, alluvial fans and river terraces.

In Himalayas, these rivers are highly tortuous, but in plains they display a strong meandering tendency and shift their courses frequently. The regimes of these rivers exhibit wide seasonal fluctuations, causing devastating floods, especially during the season of general rains. The Himalayan rivers have great socio-economic and cultural importance in the life of the Indian people. The water of the Himalayan rivers is utilised for irrigation, industries, hydel-power generation, navigation and domestic purposes.

The Peninsular Drainage System

The drainage of the Peninsular India is much older than that of the Himalayan drainage system. They are mostly seasonal. Their erosional and carrying capacity is low. Their channels are more defined and are close to the base level.

Major Drainage Basins of India

The area of land drained by a river and its tributaries is known as drainage basin. It is synonymous with river basin. On the basis of the area drained, the river basins of India may be classified into the following three categories **(Fig. 10.5)**:

(i) **Large River Basins**: River basins with catchment area of more than 20,000 sq km.

(ii) **Medium River Basins**: Area between 2,000 and 20,000 sq. km.

(iii) **Minor River Basins**: Area less than 2,000 sq km.

India has one hundred and thirteen river basins, out of which 14 are large, 44 medium and 55 minor basins.

The major river basins of India in descending of the area: (i) the Ganga, (ii) Indus, (iii) Godavari,(iv) Krishna, (v) Brahmaputra, (vi) Mahanadi, (vii) Narmada, (viii) Kaveri, (ix) Tapi, (x) Pennar, (xi) Brahmani, (xii) Mahi, and (xiii) Subarnrekha.

***Table 10.5:** Major River Basins of India*

River Basin	*Basin Area**	*Percentage Area*	*Annual Discharge (m^3/km^2)*	*%*
Ganga	861,404	26.2	468,700	25.2
Indus	321,284	9.8	79,500	4.3
Godavari	312,812	9.5	118,000	6.4
Krishna	258,948	7.9	62,800	3.4
Brahmaputra	258,008	7.8	627,000	33.8
Mahanadi	141,589	4.3	66,640	3.6
Narmada	98,795	3.0	54,600	2.9
Kaveri	87,900	2.7	20,950	1.1
Tapi	65,150	2.0	17,982	0.9
Pennar	55,213	1.7	3,238	0.2
Brahmani	39,033	1.2	18,310	1.0
Mahi	34,481	1.0	11,800	0.6
Subarnrekha	19,296	0.6	7,940	0.4
Sabarmati	21,895	0.7	3,800	0.2
Medium and Minor Rivers	711,833	23.6	-	16.0
Total	328,76,97	100.00	1,561,170	100.00

**Area means basin area in India* Source: *S.P. Das Gupta, 1989.*

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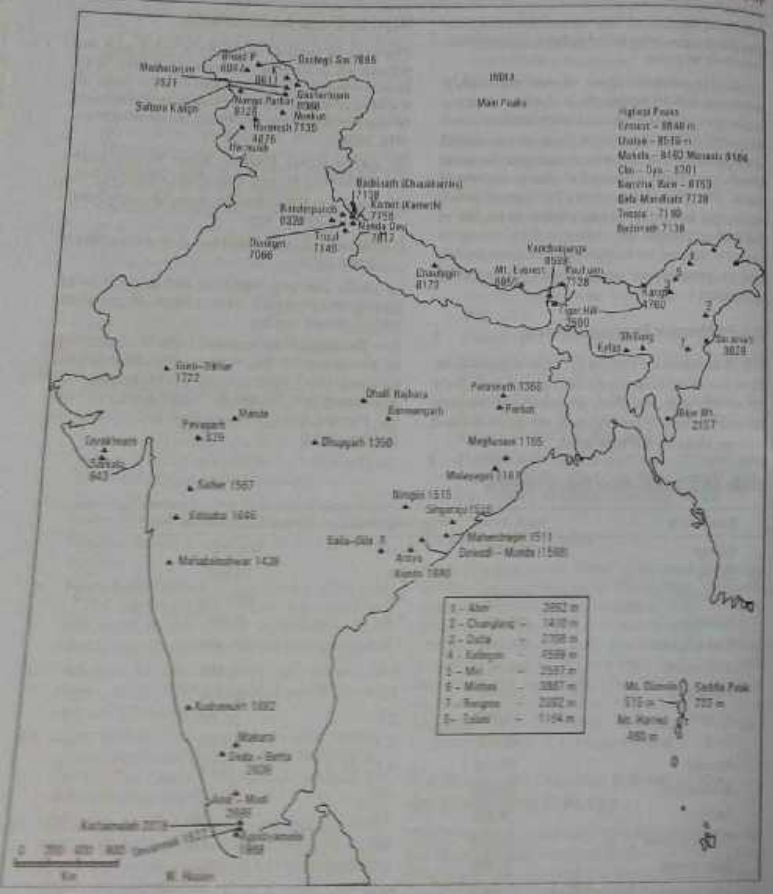

INDIA
Main Peaks
Highest Peaks
Kanchenjunga – 8848 m
Dhaulagiri – 8516 m
Makalu – 8462 Manaslu 8156
Cho – Oyu – 8201
Nanga Parbat – 8153
Gosainthan 8013
Annapurna 8078
Gurla Mandhata 7728
Trisuls – 7120
Nanda Devi 7817
Kamet (Kamet) 7756
Badrinath (Chaukhamba) 7138
Dunagiri 7066
Tirsuli 7140
Kanchenjunga 8598
Mt. Everest 8848
Chaukhamba 8172
Kailash 6740
Tirich Mir 7690
Nanga Parbat 8126
Rakaposhi 7788
Saltoro Kangri
Gurla-Mandhata 7728
Nanda Devi 7817
Kamet 7756
Dunagiri 7066
Trisul 7140
Chaukhamba 8172
Kanchenjunga 8598
Mt. Everest 8848

Fig. 10.5 – Major drainage basins of India

The longest rivers of India have been given in Fig. 10.6.

Table 10.6: *The Longest Rivers of India*

River	Length of the River (km)
1. Ganga*	2525 km
2. Godavari	1465 km
3. Krishna	1400 km
4. Yamuna	1370 km
5. Narmada	1312 km
6. Ghagra	1080 km
7. Satluj*	1050 km
8. Mahanadi	858 km
9. Kaveri	805 km
10. Son	780 km
11. Kosi	730 km
12. Brahmaputra*	725 km

*Length of the river in India

Table 10.7: *Rivers of India and their Main Tributaries*

River	Left Bank Tributary	Right Bank Tributary
1. Brahmaputra	Subansiri, Manas	Lohit, Dihang, Dibansiri, Kalang (Fig. 10.6)
2. Ganga	Alaknanda, Ramganga, Gomti, Kali (Sardaa), Sarju, Rapti, Ghagra (Karnali), Gandak, Trishuli, Burhi-Gandak, Bagmati, Kosi, Mahananda.	Yamuna, Son, Rihand, Ajay, Punpun, Phalgu, Damodar, Rupnarayan, Sitai, Haldi (Fig. 10.6)
3. Godavari	Sabari, Indravati, Paranhita Wainganga, Penganga, Wardha, Purna and Dudhana	Manjira, Tirna, Manar, Kinnarasani (Fig. 10.6)
4. Indus	Zaskar, Suru, Dras, Krishnganga, Jhelum, Chenab, Ravi, Beas, Satluj	Shyok, Nubra, Gilgit, etc (Fig. 10.6).
5. Kaveri	Herangi, Hemavati, Lokpavni, Shimsha, and Akravati	Lakshmantirtha, Kabani, Suvarnavati, Bhavani, and Amravati (Fig. 10.6)
6. Krishna	Muneru, Musi, Hallia, Bhima, Panchganga, Dudhganga,	Koyna, Malprabha, Ghataprabha, Tunghbadra (Fig. 10.6)
7. Luni	Bandi, Sukri, Jawai, Suleri	-
8. Mahanadi	Jb, Mand, Hasdeo, Sheonath	Ong, Jonk, Tel
9. Narmada	Burhner, Sanjar, Shar, Shakkar, Tawa and Kundi	Hiran, Barna, Kolar (Fig. 10.6)
10. Satluj	-	Parechhu, Spiti , Beas

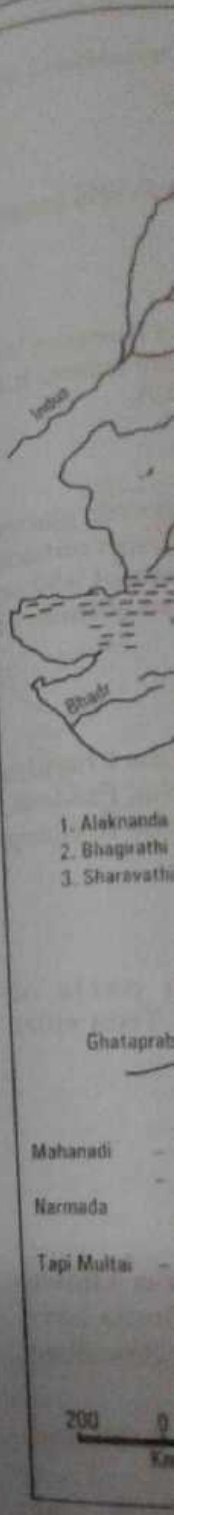
11. Tapi	Sipra, Kapra, Khursi, Mona, Purna, Girna, Panjhra	Betul, Patki, Suki, More, Arunavati, Gomai (Fig. 10.6)
12. Yamuna	Tons, Hindan	Chambal, Banas, Sind, Betwa, Dhansan, Ken

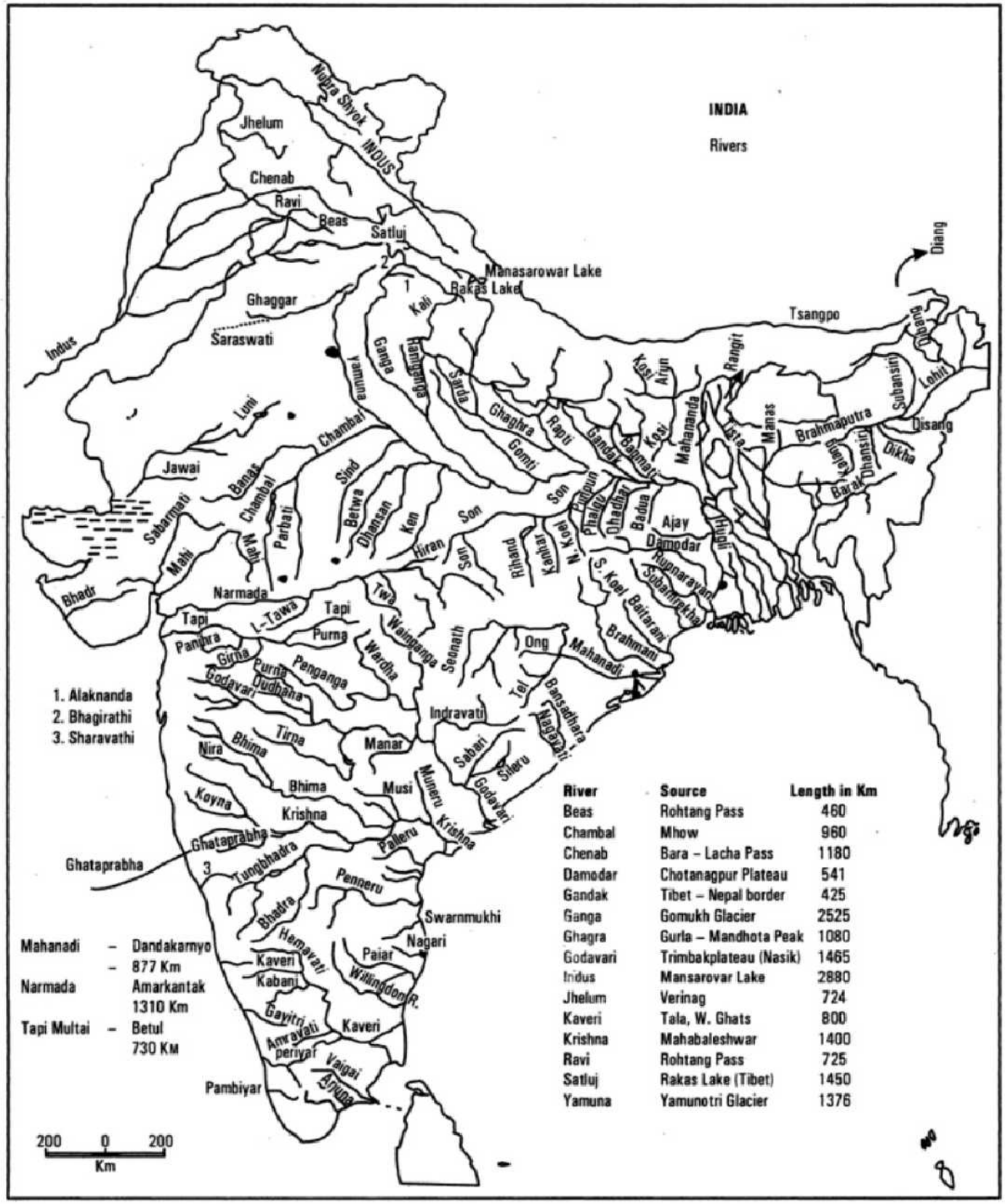
Table 10.8: *Facts about the Peninsular Rivers of India.*

River	*Source*	*Length (km)*	*Area Drained (sq km)*	*Volume of Average Annual Flow (million cubic)*	*Main tributaries*
1. Mahanadi	Dandakarnya near Sihawa in Raipur District of Chhattisgarh	857	141,600	67,000	Ib, Mand, Hasdo, Seonath, Ong, Jonk, and Tel
2. Godavari	Trimbak Plateau near Nashik in Maharashtra	1465	312,812	105,000	Manjra, Mula, Penganga, Wardha, Wainganga, Indravati, Sabari, Pranhita
3. Krishna	Near Mahabaleshwar	1400	258,948	67,670	Koyna, Ghataprabha, Malprabha, Bhima, Tungbhadra, Musi, Muneru
4. Kaveri	Taal Kaveri (W.Ghats)	800	87,900	20,950	Herangi, Hemavati, Lokpavni, Shimsha, Arkavati, Lakshmanatirath, Kabani, Suvanavati, Bhavani, and Amravati
5. Narmada	Amarkantak Plateau	1310	98,796	40,700	Hiran, Orsang, Barna, Kolar, Burhner, Banjar, Shar, Shakhar, Tawa, Kundi
6. Tapi	Multai in Betul Distt (M.P.)	730	65,145	17,980	Purna, Betul, Patkai, Ganjal, Dhatranj, Bokad, and Amravati

Main Glaciers of Indian Himalayas

Glacier is a mass of ice formed from compacted, recrystallized snow that is thick enough to flow plastically. There are nearly 15,000 glaciers in the Himalayas lying between the two syntaxial bends of the Hindukush-Karakoram Ranges (Pamir) and the Eastern Himalaya-Patkai-Bum Ranges (Arunachal Pradesh). They are of different sizes from the giants of more than 60 km to small ones only 2 to 5 km long. Almost 33,000 sq km or 17 per cent of the Himalayas is snow covered, out of which the Karakoram Range alone covers 16,000 sq. km. of ice. The snow-line is 4200 m above the sea level in the Eastern Himalayas which descends to 4000 m in the Karakoram Range. Moreover, the snowline on the Great Himalayan Ranges is at a lower





River	Source	Length in Km
Beas	Rohtang Pass	460
Chambal	Mhow	960
Chenab	Bara – Lacha Pass	1180
Damodar	Chotanagpur Plateau	541
Gandak	Tibet – Nepal border	425
Ganga	Gomukh Glacier	2525
Ghagra	Gurla – Mandhota Peak	1080
Godavari	Trimbakplateau (Nasik)	1465
Indus	Mansarovar Lake	2880
Jhelum	Verinag	724
Kaveri	Tala, W. Ghats	800
Krishna	Mahabaleshwar	1400
Ravi	Rohtang Pass	725
Satluj	Rakas Lake (Tibet)	1450
Yamuna	Yamunotri Glacier	1376

Fig. 10.6 – Rivers and their tributaries

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a lower elevation on the southern slopes than that of the northern slopes. The reason is that the southern slopes receive much greater rainfall and are also much steeper than the northern which are more gentle and much drier. Some of the important glaciers of Himalayas have been described briefly in the following **(Fig. 10.7)**

Biafo Glacier

Located in the Braldoh Valley in Karakoram, the Biafo glacier is about 59 km in length. It is the fourth longest glacier outside the polar region. Its snout occurs at an elevation of 5128 m.**(Fig. 10.7).**

Chongo Lungma Glacier

Having a length of 50 km, it is situated in the Rakaposhi Range of the Karakoram. Flowing towards the east, it terminates at an altitude of 2075 m above the sea level **(Fig. 10.7).**

Gangotri Glacier or Gaumukh Glacier

It is the source of the sacred Ganga. It is about 30 km long. The snout of this glacier lies at an altitude of 3880 m above the sea level **(Fig. 10.7).**

Gasherbrum Glacier

Situated in the Karakoram Range, it is 21 km in length. The snout of this glacier is about 4345 m above the sea level **(Fig. 10.7).**

Hispar Glacier

Having a length of 62 km, it lies in the Karakoram Range. It is the third longest glacier outside the Polar region. It flows southward and its snout is at an elevation of 3000 m **(Fig. 10.7).**

Kanchenjunga Glacier

It is 21 km long. The source of Kangchen a tributary of the Kosi river lies in this glacier **(Fig. 10.7).**

Kangto Glacier (7089 m)

It is located in the western parts of Arunachal Pradesh.

Mana Glacier

Situated along the border of Uttarakhand and Tibet, it is 18 km long.

Milam Glacier

Having a length of 20 km, it is the second longest glacier in Kumaun **(Fig. 10.7).**

Pindari Glacier

In the Trishul-Nanda Devi area of Kumaun lies the Pindari glacier. Having an easy access, it is of great tourist attraction **(Fig. 10.7).**

Siachin Glacier (5753 m)

Occupying the Nubra Valley, the Siachin glacier is 75 km in length. It is the largest glacier outside the polar region. It covers an area of 450 sq km. The snout of the glacier is at an altitude of 3705 m **(Fig. 10.7).**

Sonapani Glacier

Having a length of 18 km, it lies in the Chandra Valley (Pir-Panjal Range) of Himachal Pradesh. It rises from about 4000 m below the Rohtang Pass.

Zemu Glacier (4750 m)

Located in the north-eastern parts of Kanchenjunga, it is the source of Tista river **(Fig. 10.7).**

Major Passes of India

Pass

A route over or through mountains is known as a 'pass'. The important passes of India have been shown in **Fig. 10.8.** and briefly described in the following:

Aghil Pass: Lies between Ladakh (J & K) and Sinkiang (China).

Balcha Dhura: Connecting Uttarakhand with Tibet (China).

Banihal Pass (Jawahar Tunnel): This pass connects Banihal Town (Doda District) and

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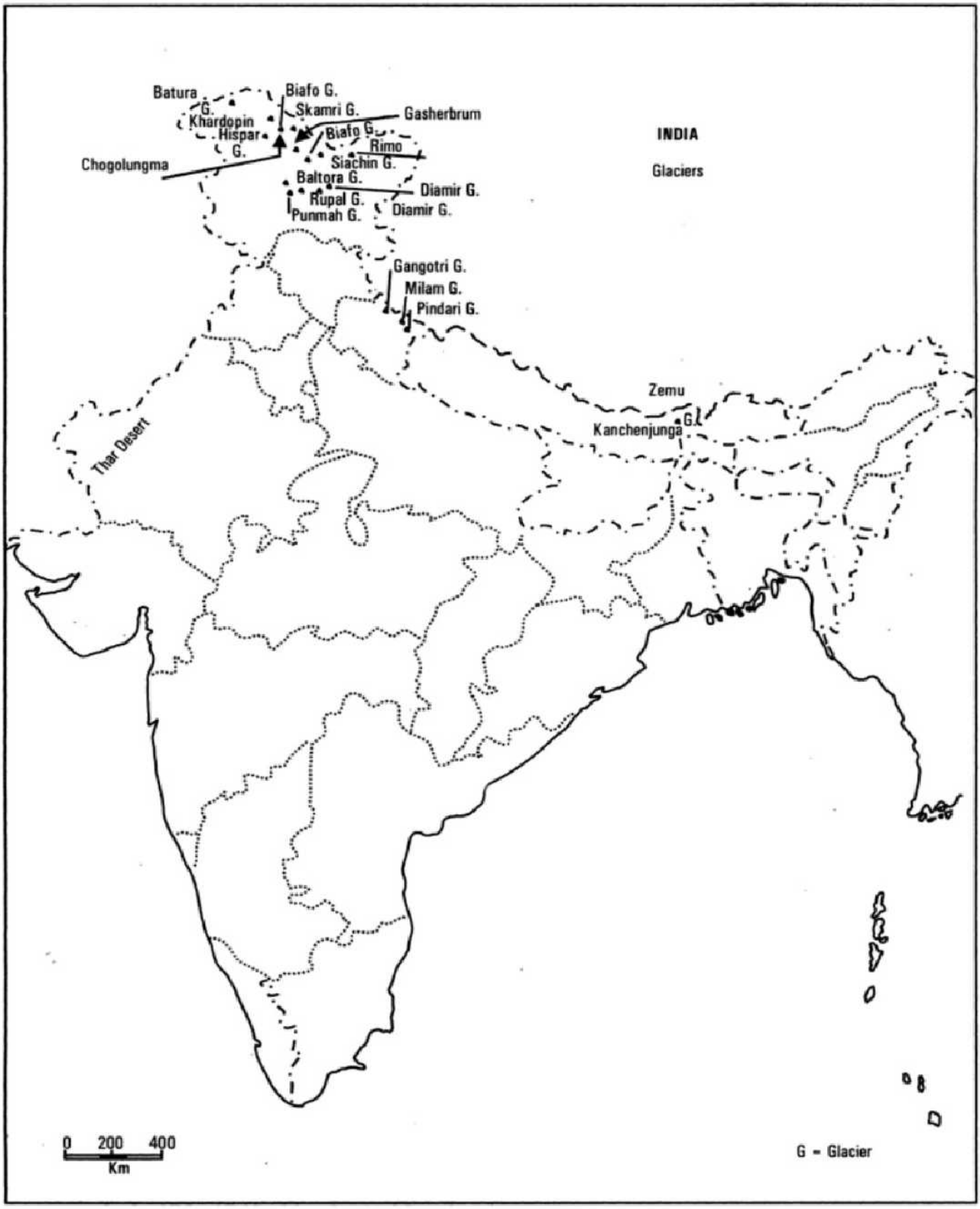

Fig.10. 7 – Main glaciers of India

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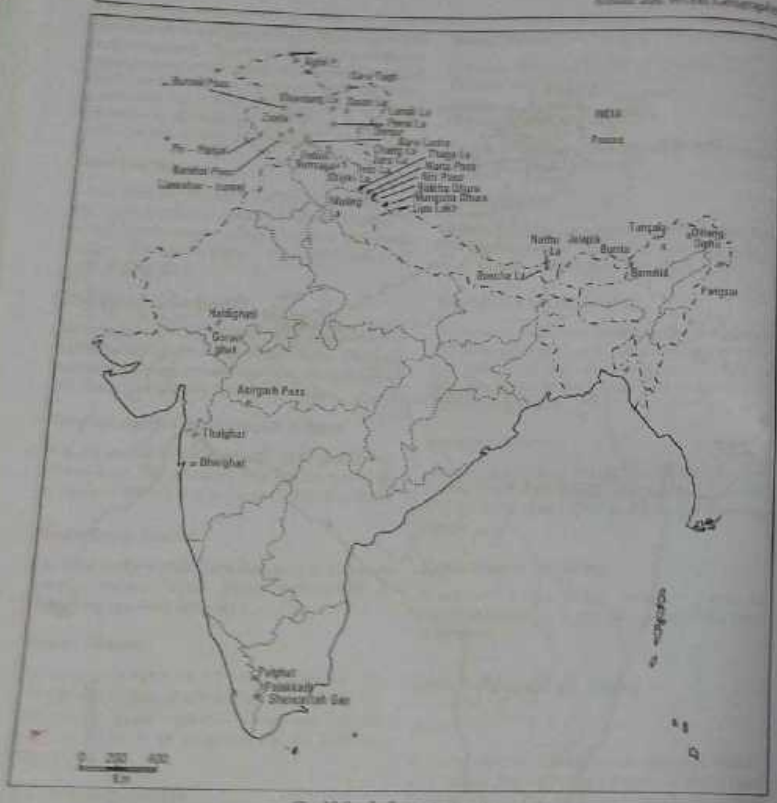

Fig 10.8 – India main passes

Qazigund Town of Anantnag (Kashmir Division).

Baralacha La: Between Kyelan and Leh (Ladakh).

Bhorghat: Between Mumbai and Nasik (Maharashtra).

Bomdila Pass: Between Tezpur (Assam) and Tawang (Arunachal Pradesh).

Bum La: Between Arunachal Pradesh and Lhasa (Tibet-China).

Chang La: Between Ladakh (J & K) and Tibet (China).

Diphu Pass: Between Arunachal Pradesh and Myanmar.

Goranghat: Between Udaipur and Sirohi (Aravallis-Rajasthan).

Jelep La: Between Gangtok (Sikkim-India) and Lhasa (Tibet-China).

Karakoram Pass: Between Ladakh (J & K) and Sinkiang (China).

Khardungla Pass: Between Leh and Siachin glaciers through Nubra Valley.

Lipu Lekh Pass: Between Uttarakhand and Tibet (China).

Mana Pass: Between Uttarakhand and Tibet (China).

Nathu La: Between Sikkim (India) and Tibet (China) entry to Chumbi Valley.

Niti Pass: Between Uttarakhand and Tibet (China).

Palghat: Between Palakkad and Coimbatore (Tamil Nadu).

Shenkotta: Between Kollam (Kerala) and Madurai (Tamil Nadu).

Shipki La: Between Himachal Pradesh (India) and Tibet (China) through the Satluj Gorge.

Thaga La: Between Himachal Pradesh and Tibet (China).

Sea Beaches

The portion of the coastline where an accumulation of sediment is in motion. In other words, it is a deposit of wave-washed sediment along a coast between the landward limit of wave action and the outermost breakers. Some of the important sea-beaches of India have been shown in **Fig. 10.9** and the names are given in **Table 10.9**.

Table 10.9: Sea Beaches of India

	State/Union Territory	Sea Beaches
1.	Andhra Pradesh	Bheemunipatnam, Manginapudi Beach, Mypadu Beach, Rishikonda Beach, Vodarevu Beach.
2.	Goa	Anjuna Beach, Agonda Beach, Arambol Beach, Colva Beach, Dona Paula Beach, Vagator Beach.
3.	Gujarat	Beyt, Dwarka, Chorwad, Gopnath, Mandvi, Navi-Bandar, Somnath, Veraval.
4.	Karnataka	Karwar, Kutle, Malpe, Maravana, Murdeshwar, Oto, Parambur, Ullal.
5.	Kerala	Alleppey, Bekal, Cherai, Kappad, Kollam, Kovalam, Lighthouse, Rockholm, Samudra, Shanngumugham, Thirumullavaram, Varkala, Veli, Vypeen and Gunda Islands.
6.	Lakshadweep	Bangram, Kadamat, Kavaratti, Minicoy.
7.	Maharashtra	Alibagh, Bassein, Borai, Chowpatty, Dhanu, Ganpatipule, Harihashwar, Manori, Janjeera, Juhu, Kihim, Malvan, Mandva, Marve, Murad, Shrivardhan, Sindhudurg, Valneshwar, Vengurla, Vijaidurg.
8.	Odisha	Bolighai, Chandipur, Chatrapur, Ghirmatha, Gopalpur, Konarak, Paradeeop, Puri.
9.	Andaman and Nicobar Islands	Chariya Tapu, Wandoor, Corbyn Cave, Kaminada Island, Mahabalipuram, Mandapam, Neil Island, Sadurangapatinam.

10.	Puducherry	Beaches of Puducherry
11.	Tamil Nadu	Covelong, Marina, Pichvaram, Pulicat, Vattikottai
12.	West Bengal	Digha, Frazergani, Ganga Sagar, Shankarpur
13.	Daman	Devaka Beach, Jayopore Beach
15.	Diu	Chikratith, Jallandhar, Nagoa

Lakes

Lakes are the static bodies of water that are surrounded by land on all sides. They vary in size and depth. Caspian Sea is the largest lake in the world followed by the Superior (North America), and Victoria (Africa). In India Chilka Lake is the largest salt water lake, while the Wular is the largset fresh water lake. The important lakes of India have been shown in **Fig. 10.10**, while **Table 10.10** gives their location.

Table 10.10: Lakes of India

	Lake	*State*
1.	Asthamudi (Lagoon)	Kerala
2.	Bhimtal	Uttarakhand
3.	Chilka (Lagoon)	Odisha
4.	Dal Lake	Kashmir (J & K)
5.	Kolleru	Andhra Pradesh
6.	Loktak	Manipur
7.	Lonar	Maharashtra
8.	Naini Tal	Uttarakhand
9.	Nakki Lake	Rajasthan
10.	Nizam Sagar	Hyderabad (Andhra Pradesh)
11.	Parashuram Kund	Arunachal Pradesh
12.	Pong Morari	Ladakh (J & K)
13.	Pulicut	Andhra Pradesh
14.	Pushkar Lake	Rajasthan
15.	Salt Lake	Kolkata
16.	Sambhar Lake	Rajasthan
17.	Tso Moriari	Ladakh (J & K)
18.	Udaipur Lake (Panchola)	Rajasthan
19.	Upper and Lower Lakes	Bhopal (Madhya Pradesh)
20.	Vembnad Kayal (Lagoon)	Kerala
21.	Wular Lake	Kashmir (J & K)

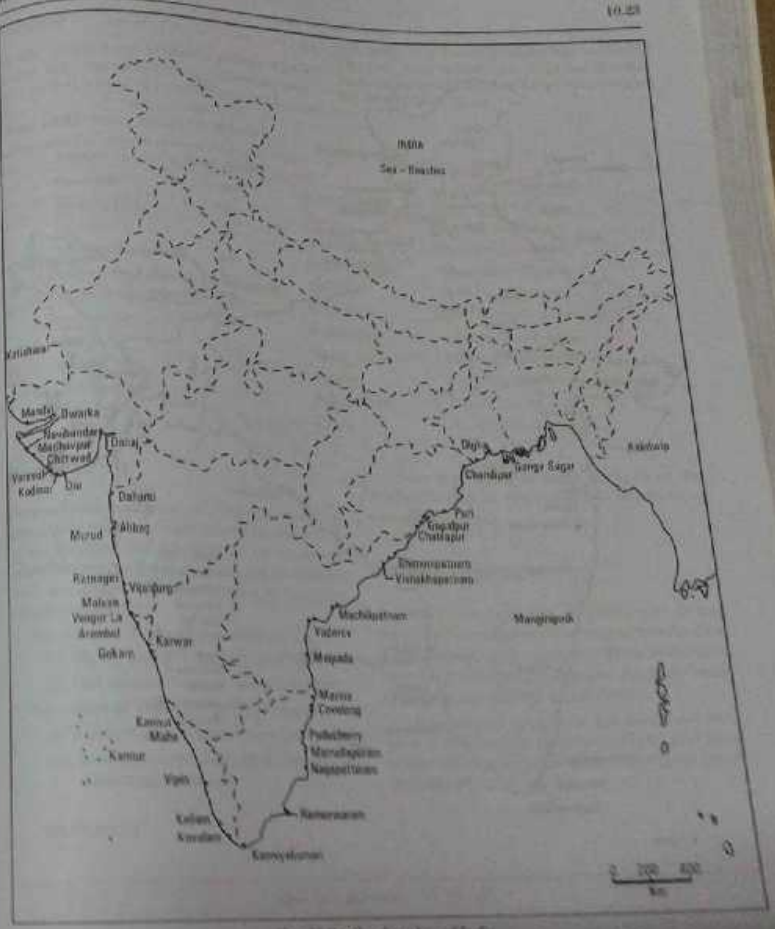

Fig. 10.9 – Sea-beaches of India

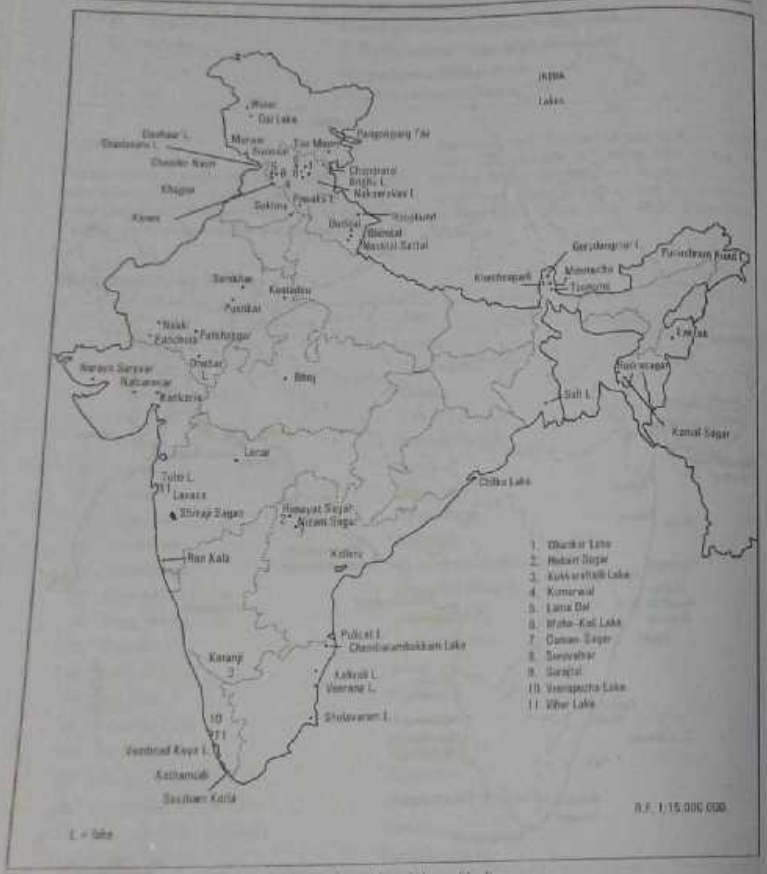

Fig. 10.10 – Main lakes of India

Waterfall

A site on the long profile of a river where water falls almost vertically. Waterfalls may be found at a band of more resistant rock, at a nick point, or where deposition has occurred. There are many waterfalls in India. Some of the important waterfalls of India have been shown in **Fig. 10.11 (Table 10.11)**.

Table 10.11: Major Waterfalls of India

	Waterfall	Height (metres)	River	State
1.	Barehipani	399	Buchabalanga	Mayurbhanj (Odisha)
2.	Barkana Falls	259	Sita	Shimoga (Karnataka)
3.	Jog Falls	253	Sharavati	Shimoga (Karnataka)
4.	Khandadhar Falls	244	Korapani Nala	Sundargarh (Odisha)
5.	Vantawng Falls	229	Lau River	Serchhip (Mizoram)
6.	Magod Falls	198	Bedti River	Uttar Kannada (Karnataka)
7.	Lodh Falls	143	Budha River	Latehar (Jharkhand)
8.	Chachai	130	Bihad	Madhya Pradesh
9.	Bundla	100	Bundla	Kangra (Himachal Pradesh)
10.	Hundru Falls	99	Subernrekha	Ranchi (Jharkhand)
11.	Teerathgarh	91	Kaga	Bastar (Chhattisgarh)

Monsoon

Derived from the Arabic word *mausim*, meaning season, the term originally referred to the winds of the Arabian Sea which blow for about six months from the north-east and for six months from the south-west. The seasons in India are divisible as under:

1. The season of the north-east monsoon:
   (i) Winter season – January and February
   (ii) Hot weather season – March to May
2. The season of the south-west monsoon:
   (i) Season of general rains – June-September
   (ii) Post-monsoon season or season of retreating monsoon.

Over most parts of India the bulk of the rainfall comes in the season of south-west monsoon.

Natural Vegetation

In theory, the grouping of plants which has developed in an area without human interference is known as natural vegetation. Most landscapes have been changed by humans through forest clearance, agriculture, and industry.

It is argued that there are relatively few areas truly natural vegetation left. The area under different types of forest have been given in **Table 10.12**.

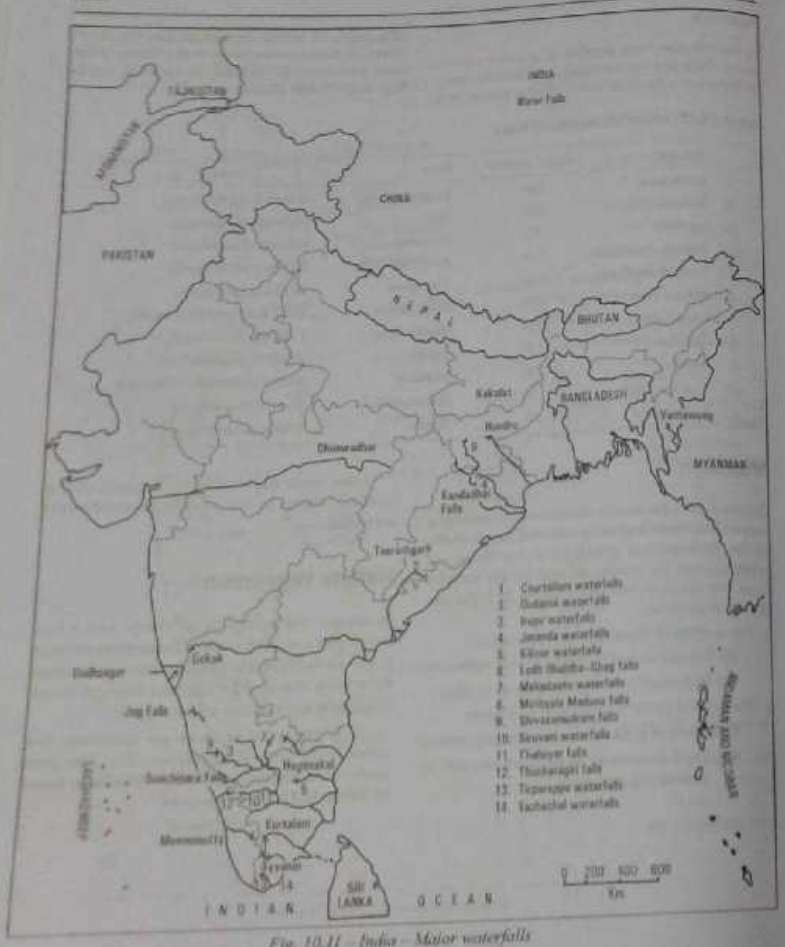

Fig. 10.11 – India – Major waterfalls

Table 10.12: India – Area Under Forests

	Forest Type	Area (million hectares)	Percentage of Total Area
1.	Tropical Moist Deciduous	25.680	37.0
2.	Tropical Dry Deciduous	18.304	28.6
3.	Tropical Wet Evergreen	5.120	8.0
4.	Sub-Tropical Moist Hill (pines)	4.224	6.6
5.	Tropical Semi-evergreen	2.624	4.1
6.	Montane Wet Temperate	2.304	3.6
7.	Himalayan Moist Temperate	2.176	3.4
8.	Tropical Thorny Forests	1.664	2.6
9.	Subtropical Dry Evergreen	1.600	2.5
10.	Alpine	1.344	2.1
11.	Littoral and Swamps	0.384	0.6
12.	Subtropical Broad-Leaved	0.256	0.4
13.	Himalayan Dry Temperate	0.192	0.3
14.	Tropical Dry Evergreen	0.128	0.2
	Total	**64.800**	**100.00**

The percentage share of forests in the different geographical regions of India has been given in **Table 10.13**.

Table 10.13: India – Geographical Distribution of Forest

	Region	Percentage of Total Forest Area of India
1.	Peninsular Plateau and Hills	57.50
2.	Himalayan region	18.00
3.	Western Ghats and Western Coastal Plains	10.50
4.	Eastern Ghats and Eastern Coastal Plains	9.50
5.	The Great Plains of India	5.00
	Total	**100.00**

Biosphere Reserves

Multi-purpose protected areas to preserve genetic diversity in representative ecosystem. The boundaries of a biosphere are fixed by legislation. Tourism normally not permissible. Research and educational activities are promoted and properly managed. The biosphere reserves of India have been shown in **Fig. 10.12**.The names of the states where these biosphere reserves are located are given in **Table 10.14**.

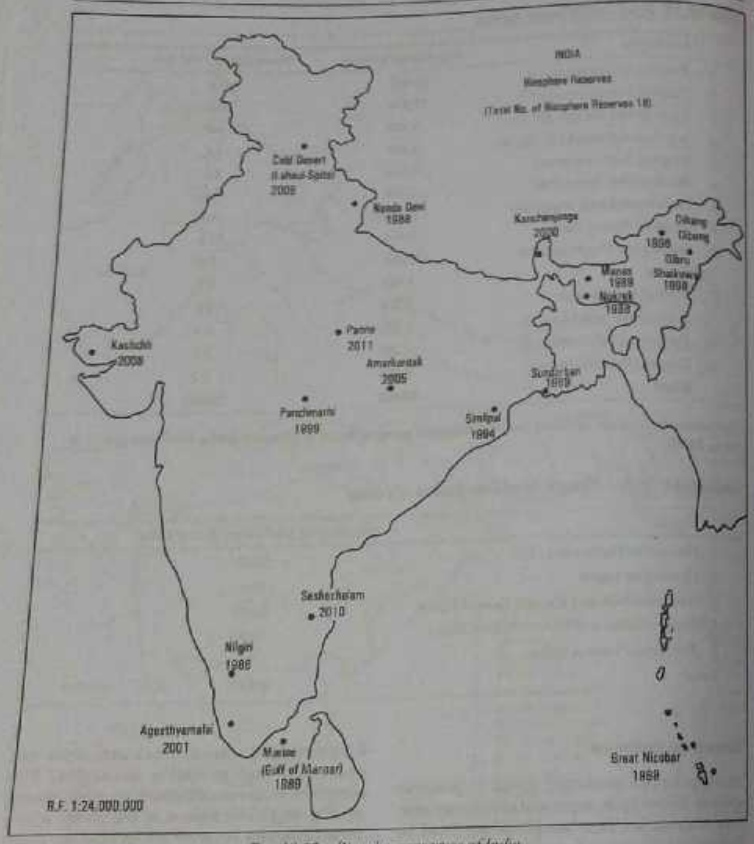

Fig. 10.12 – Biosphere reserves of India

Table 10.14: Biosphere Reserves of India

Biosphere Reserve	State
1. Agasthyamalai	Kerala
2. Amarkantak	Madhya Pradesh
3. Dibang-Dibang	Arunachal Pradesh
4. Dibru-Saikhowa	Assam
5. Great Nicobar	Andaman and Nicobar Islands
6. Kachchh	Gujarat
7. Manas	Assam
8. Marine (Gulf of Mannar)	Tamil Nadu
9. Nandadevi	Uttarakhand
10. Nilgiri	Tamil Nadu
11. Nokrek	Garo Hills (Meghalaya)
12. Panchmarhi	Madhya Pradesh
13. Simlipal	Odisha
14. Sundarban	West Bengal
15. Cold Desert (Lahaul-Spiti)	Himachal Pradesh
16. Seshachalam	Andhra Pradesh
17. Kanchenjunga	Sikkim
18. Panna	Madhya Pradesh

National Park

A reserved area meant for preserving its natural vegetation, wildlife, natural beauty and ethnic culture. It is the habitat for some particular wild animals.

Its boundaries are fixed by legislation. While tourism is permissible, research and scientific management are lacking in Indian national parks. The national parks, bird sanctuaries and tiger reserves of India have been shown in **Fig. 10.13**, while **Table 10.15** gives their names and the states they are located in.

Sanctuary

A reserved area meant for preservation and development of endangered species. Generally species-oriented such as citrus, pitcher plant, etc. Boundaries are not fixed. Limited biotic interference. Tourism is permissible, but research and scientific management are lacking in Indian sanctuaries.

Table 10.15: National Parks, Tiger Reserves and Bird Sanctuaries

State/Union Territory	Reserve	Status	Specialities
1. Andhra Pradesh	(i) Kolleru	Bird Sanctuary	
	(ii) Nagarjuna Sagar	National Park	Tiger Reserve
2. Arunachal Pradesh	Nam Dhapa	National Park	Tiger Reserve
	Pakhui Nameri		Tiger Reserve
3. Assam	(i) Kaziranga	National Park	Habitat of endangered Rhinoceros
	(ii) Manas (Barpeta Distt.)	National Park	Tiger Reserve

4. Bihar	(i) Buxar	National Park	Tiger Reserve
	(ii) Valmiki	National Park	Tiger Reserve
5. Chhattisgarh	Indravati	National Park	Tiger Reserve
6. Goa	(i) Mahavir	National Park	-
	(ii) Mollem	National Park	
7. Gujarat	(i) Gir	National Park	Tiger Reserve (Asiatic Lions)
	(ii) Valvadar (Bhavnagar)	National Park	
	(iii) Rann of Kachchh	Wildlife Sanctuary	Indian Wild Ass Sanctuary
8. Haryana	Sultanpur Lake	Birds Sanctuary	-
9. Himachal Pradesh	(i) Great Himalayan National Park	National Park	
	(ii) Kugati	Wildlife Sanctuary	
10. Jammu & Kashmir	(i) Dachigam (Srinagar)	National Park	Kashmiri Stag
	(ii) Hamis (J & K)	National Park	
11. Jharkhand	(i) Betla	National Park	-
	(ii) Palamau (Daltenganj)	National Park	Tiger Reserve
12. Karnataka	(i) Bandipur	National Park	Tiger Reserve
	(ii) Bannregatta(Bengaluru)	National Park	-
	(iii) Bhadra	National Park	Tiger Reserve
	(iv) Nagarhole (Kodau)	National Park	
13. Kerala	(i) Eravikulam-Rajamalai (Idukki Distt.)	National Park	-
	(ii) Periyar (Idukki)	National Park	Wild Elephents and Tiger Reserve
	(iii) Silent Valley	National Park	
14. Madhya Pradesh	(i) Bandhavagarh (Shahdol Distt.)	National Park	Tiger Reserve
	(ii) Bori-Satpura	National Park	Tiger Reserve
	(iii) Kanha(Mandla & Balaghat)	National Park	Tiger Reserve
	(iv) Panna Tiger Reserve	Wild Life Sanctuary	Tiger Reserve
	(v) Pench	Wild Life Sancturay	Tiger Reserve
	(vi) Shivpuri (Madhav)		
	(vii) Tadoba (Chandrapur)	National Park	-
15. Maharashtra	(i) Borivli (Greater Mumbai)	National Park	-
	(ii) Melghat (Amravati Distt.)	Tiger Reserves	Tiger Reserve
	(iii) Nawegaon (Bhandara)	National Park	-
	(iv) Pench (Nagpur)	National Park	-
	(v) Tadoba Andharai	Wild Life Sancturay	Tiger Reserve
16. Manipur	Kaibul Lamjao (Churachandpur)	National Park	-

17. Meghalaya	Balpakhran (Garo Hills)	National Park	-
18. Mizoram	Dampha	National Park	Tiger Reserve
19. Nagaland	Intaki	National Park	-
20. Odisha	(i) Gahirmatha	Wildlife Sanctuary	Sea turtles (Olive Ridley)
	(ii) Nandankanan	National Park	Habitat-White Tigers
	(iii) Simlipal (Mayurbhanj	Wild Life Sanctuary	Tiger Reserve
21. Punjab	(i) Abohar	Wild Life Sanctuary	-
22. Rajasthan	(i) Keoladeo Ghana (Bharatpur Distt)	National Park, Bird Sanctuary	Bird Sanctuary
	(ii) Ranthambore (S. Madhopur)	Wildlife Reserve National Park	Tiger Reserve
	(iii) Sariska (Alwar Distt.)	National Park	Tiger Reserve
23. Sikkim	Kanchenjunga	National Park	-
24. Tamil Nadu	(i) Guindy	National Park	-
	(ii) Kalakad Mundanthurai	-	Tiger Reserve
	(iii) Mudumalai (Nilgiri)	National Park	-
25.Uttarakhand	(i) Jim Corbett (Nainital)	National Park	Tiger Reserve
	(ii) Nanda Devi	National Park	Bioshphere Reserve
	(iii) Valley of Flowers	National Park	-
26.Uttar Pradesh	Dudwa (Distt.Kheri)	National Park	Tiger Reserve
27.West Bengal	(i) Buxa	Wildlife Sanctuary	Tiger Reserve
	(ii) Sundarbans (24-Parganas)	Wildlife Sanctuary	Tiger Reserve (Bengal Tigers)
Union Territories			
Andaman and Nicorbar Islands	(i) Mount Harrier	National Park	Biosphere
	(ii) Saddle Peak	National Park	Reserve

Project Tiger

It is a centrally sponsored project which was launched in February 1992 to provide financial and technical support to major tiger bearing states in the country for the protection of tigers, their habitat and corridors. The project is being implemented in 13 states, namely: Andhra Pradesh, Arunachal Pradesh, Assam, Jharkhand, Karnataka, Kerala, Meghalaya, Nagaland, Odisha, Tamil Nadu, Uttarakhand, Uttar Pradesh and West Bengal. The main tiger reserves in India under the project tigers are **(Fig. 10.13).**

1. Anamalai – Parambikulam (Tamil Nadu)
2. Barail-Saifung (Assam and Meghalaya)
3. Dalma Wildlife Sanctuary (Jharkhand)
4. Kameng-Sonitpur (Arunachal Pradesh and Assam)
5. Kaziranga-Karbelong-Intaki (Assam and Nagaland)
6. Nilambur-Silent Valley (Kerala and Tamil Nadu)
7. Periyar-Madurai (Tamil Nadu)
8. Rajaji-Corbett (Uttarakhand)

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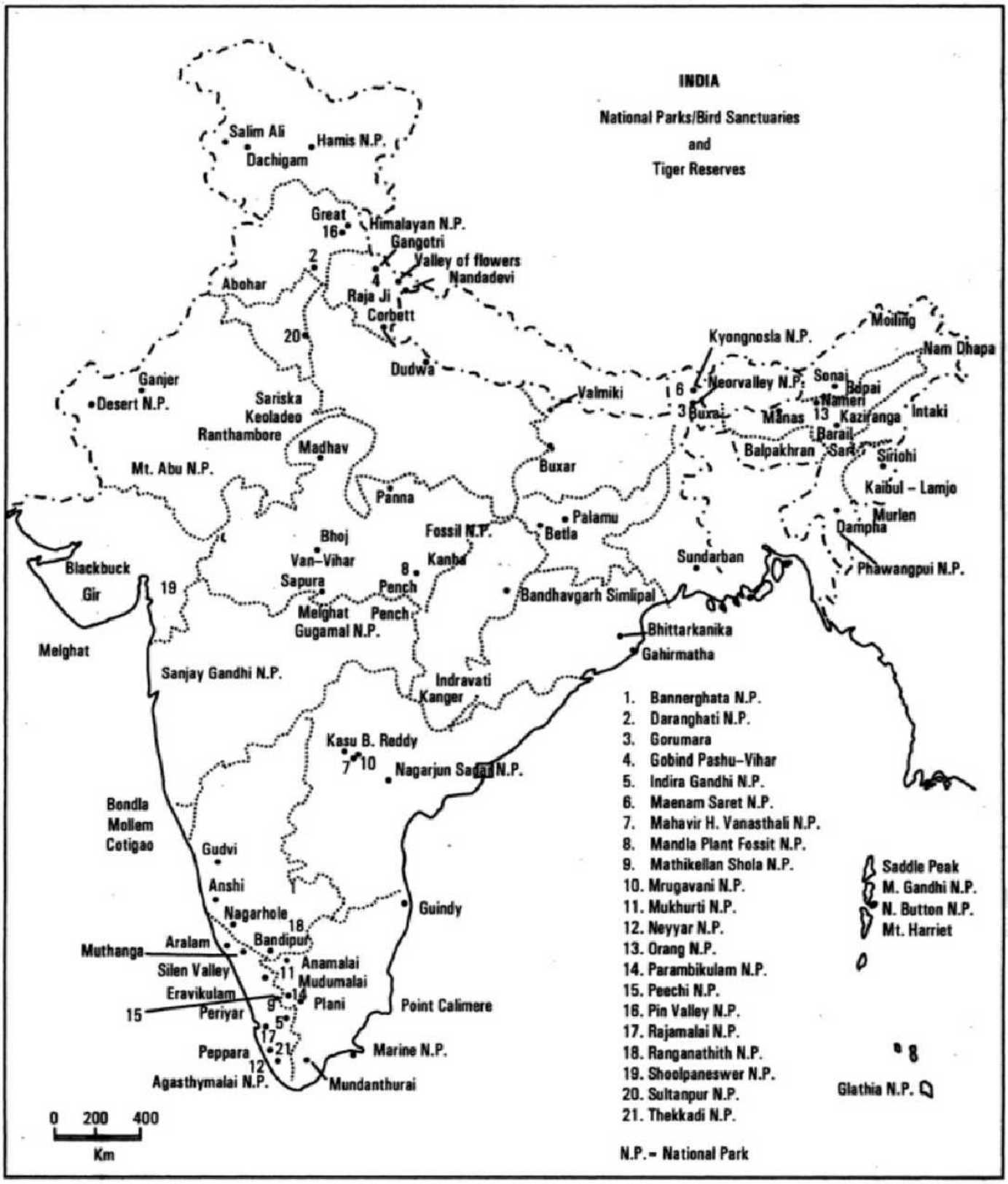

Fog. 10.13 – National parks, bird sanctuaries and tiger reserves of India

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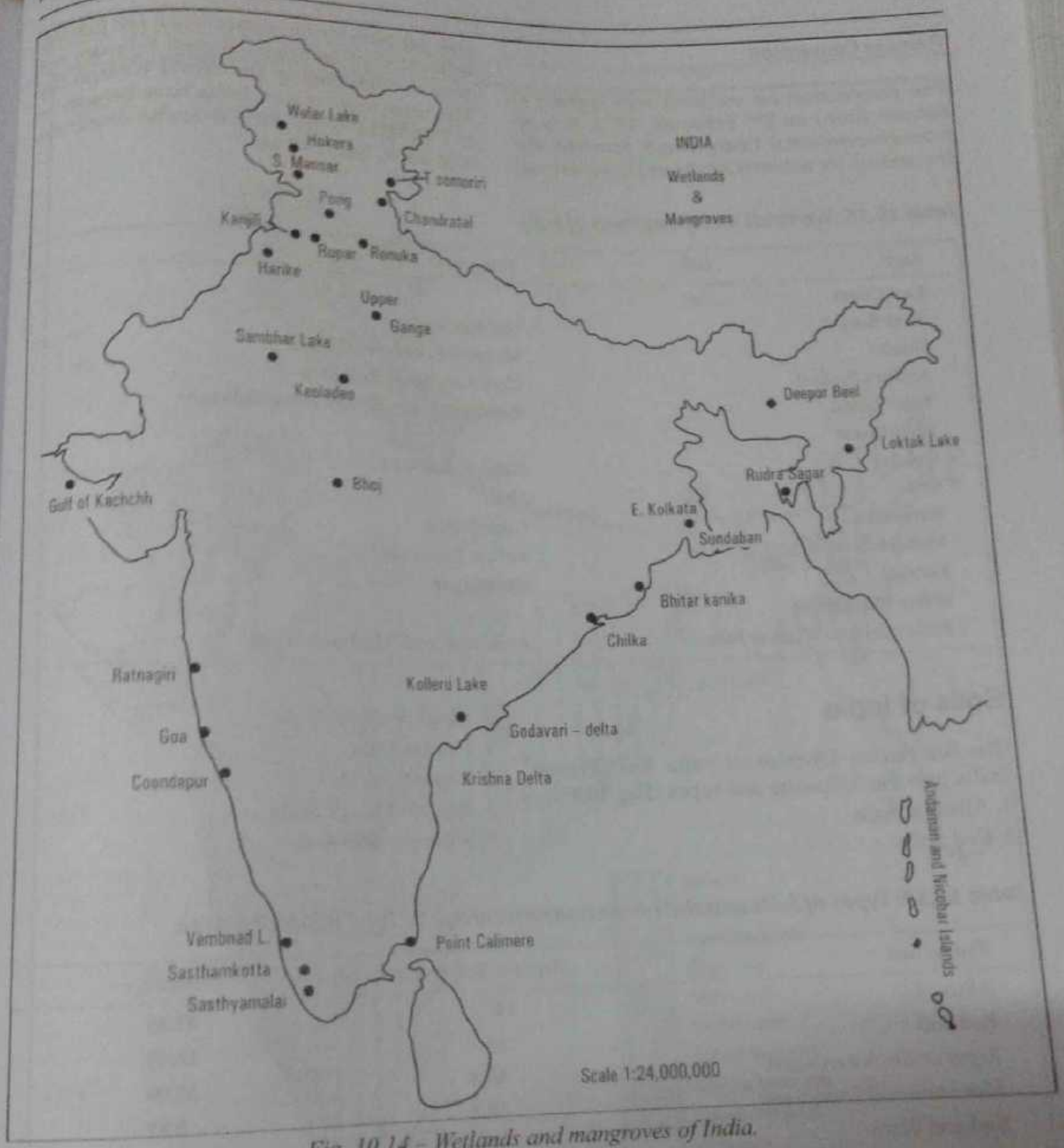

Fig. 10.14 – Wetlands and mangroves of India.

Crocodile Projects

The Crocodile Project in India was initiated in 1975. The main objective of the project was to conserve and protect crocodiles of India from extinction.

The *Gahirmatha* (Odisha) is one of crocodile projects **(Fig. 10.13)**. A Crocodile Bank has been established at Chennai to conserve and protect the natural habitat of the crocodiles.

Ramsar Convention

The convention on wetland was signed at Ramsar (Iran) on 2nd February, 1971. It is an inter-governmental treaty which provides the framework for national action and international co-operation for the conservation and judicious utilisation of wetlands. Second February each year is celebrated as the World Wetland Day.The main wetlands of India have been shown in **Fig. 10.14**, while their statewise distribution is given in **Table 10.16**.

Table 10.16: Wetlands and Mangroves of India

State	*Mangrove*
East Coast	
West Bengal	Sundarban
Odisha	Mahanadi, Bhaitarakanika
Andhra Pradesh	Godavari, Krishna deltas
Tamil Nadu	Pichvaram, Muthupet, Point Calimere
West Coast	
Gujarat	Gulf of Kachchh
Goa	Goa
Karnataka	Coondapur
Maharashtra	Achar, Ratnagiri
Kerala	Vambanad
Other Mangroves	
Andaman and Nicobar Islands	Andaman and Nicobar Islands

Soils of India

The Soil Survey Division of India has divided India into the following soil types **(Fig. 10.15)**:

1. Alluvial Soils
2. Red Soils
3. Black Soils or *Regur*
4. Desert Soils
5. Lateritic Soils
6. Red and Black Soils
7. Submontane Soils

Table 10.17: Types of Soils and their Area and Percentage to Total Reporting Area.

Type of Soil	*Area (million hectares)*	*Percentage*
Alluvial	143.1	43.36
Red Soil	61.0	18.49
Regur or Black earth-soil	49.8	15.09
Mountain Soil Desert soil	18.2	5.51
Red and Black	17.8	5.40
Desert Soil	14.6	4.42
Lateritic Soil	12.2	3.70
Other Soils	13.3	4.03
Total	330.0	100.00

Source: Chatterji, S.P., 1973 & 1986.

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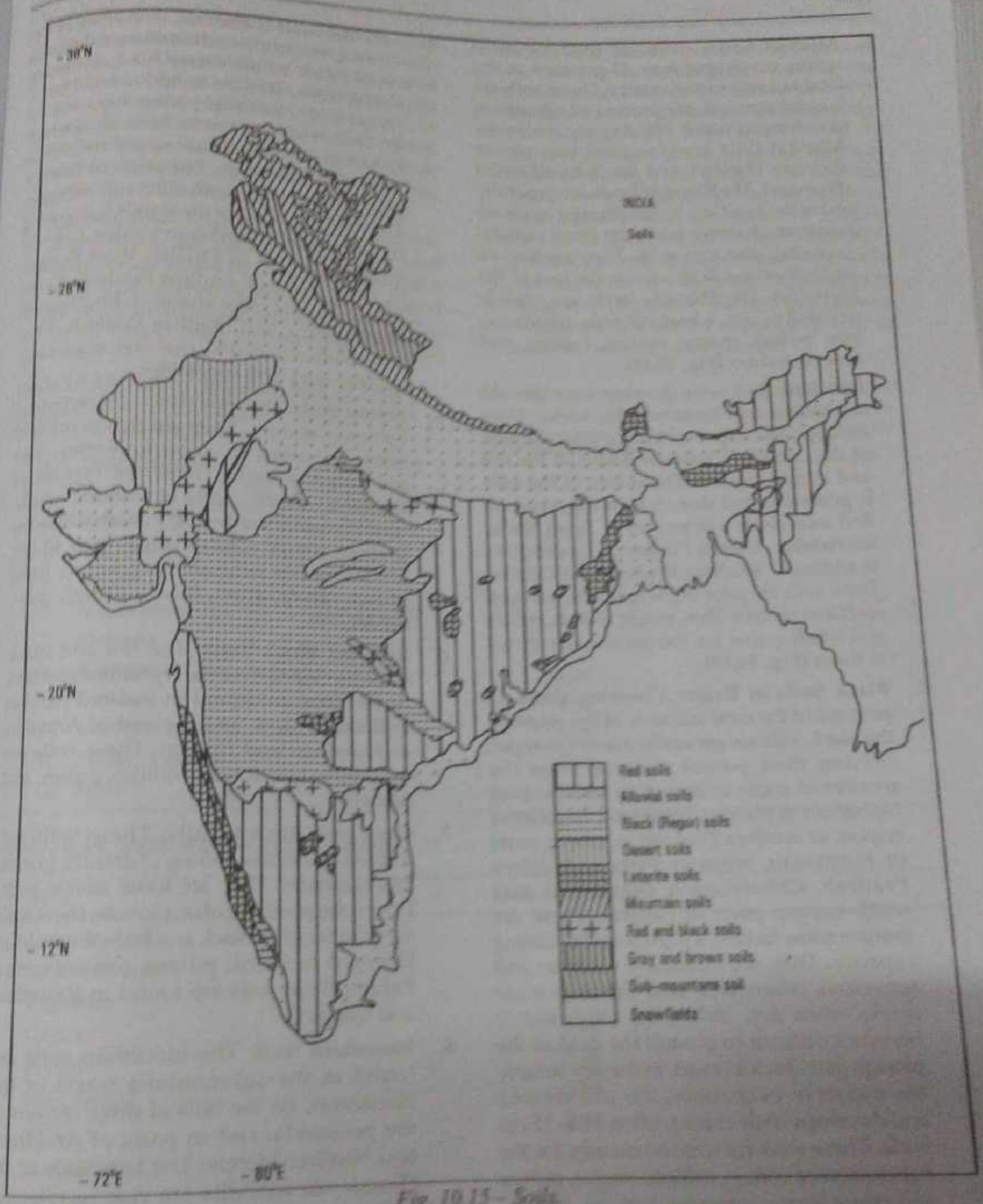

Fig. 10.15 – Soils

1. **Alluvial Soils**: Alluvial soils are most fertile, occupying over 43 per cent of the total soil area of the country. These soils are formed through the process of deposition of sediments (sand, silt, clay, etc.) in layers. Alluvial soils are classified into newer alluvium (Khadar) and the older alluvium (Bhangar). The Bhangar lands are generally above the flood levels. The Bhangar lands are however, characterised with Khors (winds-deposits), and kan soils. They are known as Bhabhar and Tarai soils at the foot of the Shiwaliks. The Bhangar lands are mainly devoted to rice, wheat, oilseeds, sugarcane, pulses, maize, millets, fodder, and tobacco-fodder (**Fig. 10.15**).

2. **Red Soil**: Red soils develop over the old crystalline and metamorphic rocks. They occupy over 18 per cent of the total soil area of the country. These are found in the hot and humid regions. The colour of the soils is generally red due to high iron content. Red soils cover a large part of Tamil Nadu, Karnataka, Andhra Pradesh, Chhattisgarh, Jharkhand, Madhya Pradesh and Odisha. These soils are poor in phosphorus, nitrogen and lime content. Rice, maize, millets, pulses and small grains are the main crops grown in them (**Fig. 10.15**).

3. **Black Soils or Regur**: Covering about 15 per cent of the total soil area of the country, the black soils are generally known as regur. Getting their parent material from the weathered rocks of lava, they stretch over Maharashtra plateau, Telengana, Rayalseema region, of Andhra Pradesh, northern parts of Karnataka, western parts of Madhya Pradesh, Chhattisgarh, Jharkhand, and south-western parts of Gujarat. These are mature soils, having a high water retaining capacity. They are extremely compact and tenacious when wet and develop wide cracks when dry. When the soil is wet, it becomes difficult to plough the field as the plough gets stuck around. In the dry season, the moisture evaporates, the soil shrinks and develops wide cracks, often after 15 cm wide. These soils are utilised mainly for the cultivation of cotton, millets, maize, pulses and rice, wheat, oilseeds, sugarcane, etc.

4. **Lateritic Soils (Latosols)**: The name of the lateritic soils has been derived from the Latin word *later* which means brick. These are the typical soils of the monsoon and humid tropical or equatorial zones characterised by deep weathered layer from silica which has been leached. These soils are rich in iron and aluminium, but poor in humus, phosphorous, potassium, lime and nitrogen. The reddish colour of these soils is imparted by the iron and aluminium residue. Lateritic soils are found in Orissa, West Bengal, in some parts of Andhra Pradesh, Tamil Nadu, Kerala, Jharkhand, Chhattisgarh, Maharashtra, and Madhya Pradesh. They are mainly devoted to rice, ragi, sugarcane, cashew nuts, and vegetables.

5. **Desert Soils**: Desert soils are characterised by sandy texture. They are rich in mineral salts, but poor in organic matter. The pH value is high. These are typical of Rajasthan desert, parts of Gujarat, south-west Haryana, south-west Punjab where the average annual rainfall is less than 40 cm. These soils are generally devoted to *bajra*, pulses (green-gram, black- gram) *guar*, fodder, etc.

6. **Red and Black Soils**: The red and black soils developed over the crystalline and lava rocks. They are found in isolated patches in Bundelkhand, and the east of Aravallis in Rajasthan and Gujarat. These soils are devoted to maize, bajra, millets, pulses, and oilseeds.

7. **Grey and Brown Soils**: These soils are formed by the weathering of granite, gneiss, and quartzite. They are loose friable soils. Due to the presence of iron-oxide, these soils vary from red to black and brown in colour. Devoted to bajra, pulses, oilseeds and fodder. These soils are found in Rajasthan and Gujarat.

8. **Mountain Soil**: The mountain soils are found in the sub-montane parts of the Himalayas, on the hills of lower regions of the peninsula, and in parts of Jammu and Nicobar islands. The new soils of the Himalayan riverbeds are rich in nitrogen and organic matter, is cultivated on

of Jammu & Kashmir, Himachal Pradesh, Uttarakhand, and Sikkim, brown podzol soils are found. Alpine meadow soils are located at further higher altitudes. Mountain soils having a good vegetation cover are rich in organic matter, but their base-status varies, depending on the degree of leaching. These soils are generally devoted to maize, pulses, oilseeds and fodder.

9. **Karewa Soils**: Karewas are the lacustrine deposits in the Valley of Kashmir and Bhadarwah Valley of the Jammu Division of J & K. Karewas are the flat topped mounds that border the Kashmir Valley on all sides. They are composed of fine silt, clay, sand, and boulder gravel. According to geologists, during the Pleistocene Period, the entire valley of Kashmir was under water. Subsequently, the Baramullah Gorge was created by the endogenetic forces, and the lake was drained through this gorge. The deposits left in the process are known as karewas. The karewa soils are devoted mainly to the cultivation of saffron, almond, walnut, apricot, apple and peach orchards. The karewas of Pampur, Pulwama and Kulgam (Kashmir Valley) are famous for the cultivation of superior quality of saffron, walnut, and almond.

Table 10.18: India – Salinity Affected Area

	State/Union Territory	Area (lakh hectares)
1.	Uttar Pradesh	12.95
2.	Punjab	12.25
3.	Gujarat	12.14
4.	West Bengal	8.50
5.	Rajasthan	7.29
6.	Maharashtra	5.34
7.	Haryana	5.26
8.	Karnataka	4.04
9.	Odisha	4.04
10.	Madhya Pradesh	2.24
11.	Andhra Pradesh	0.42
12.	Bihar	0.04

Table 10.19: India–Ravine Affected Areas

State	Area (lakh hectares)
Uttar Pradesh	12.36
Madhya Pradesh	6.85
Rajasthan	4.55
Gujarat	4.00
Punjab	1.28
West Bengal	1.04
Bihar	0.65
Tamil Nadu	0.58
Maharashtra	0.28

Water Resources of India

Water is our most precious resource. It is, however, limited and unequally distributed. India has only 4% of water resources of the world, while it has to support about 17% of the world population and over 15% the livestock. The average annual precipitation is the main source of water in the country, is estimated to be of the order of 4000 Billion Cubic Metres (BCM). The estimated precipitation during the monsoon season (June-September) is 3000 BCM or 75% of the annual precipitation. With the rapid growth of population, industrialisation and urbanisation, the demand for water is increasing at a faster pace. The Ministry of Water Resources lays down policies and programmes for the development, regulation and judicious utilisation of water resources. The average annual water availability of the country is assessed as 1869 billion cubic metres (BCM). Of this, total utilisable water resource is assessed as 1123 BCM, surface water 690 BCM and groundwater 433 BCM.

Irrigation

Indian agriculture is often been called as *"a gamble on monsoon"*. In the areas of high variability of rainfall, the availability of irrigation can make the cultivation of crops more reliable and sustainable. In fact, irrigation is vital for realising full potential of agricultural sector. Efficient utilisation of our water resources, therefore, assumes great significance. Drought is an annual phenomenon in some parts of the country. The delayed arrival of monsoon often reduces the agricultural returns. Moreover, the winter crops are largely dependent on irrigation. To solve all these problems, irrigation is needed. From time immemorial irrigation has been practiced in India, and now it ranks first in the world in terms of total irrigated area. The main irrigation sources and the areas irrigated by them are given in **Fig. 10.16.**

Canals

Canals are one of the oldest and most important sources of irrigation in India. Canal irrigation is, however, largely confined to the Great Plains of India (Punjab, Haryana, Uttar Pradesh, Uttarakhand, Rajasthan, Bihar and West Bengal), and the fertile plains of India (Andhra Pradesh, Karnataka, Madhya Pradseh, Odisha, and Tamil Nadu). The Bari Doab Canal, Bhakhra Canal, Indira Gandhi Canal, Eastern and Western Yamuna Canals, The Ganga Canal, Agra and Sharda Canals are some of the important irrigation systems of India. The canal irrigation has transformed certain areas of the Thar Desert into fertile green areas in the Indira Gandhi Canal Command Area.

Table 10.20: Area under Canal Irrigation of the Selected States

	State	Net Area under canal irrigation (thousand hectares)	Percentage of canal irrigated area to net irrigated area of the state	Percentage of canal irrigated area in the state of total irrigated area of India
1.	Uttar Pradesh	3090	25.42	21.33
2.	Andhra Pradesh	1650	36.42	10.83
3.	Haryana	1475	49.89	9.68
4.	Rajasthan	1355	27.59	8.90
5.	Bihar	1135	31.34	7.45
6.	Maharashtra	1050	35.38	6.89
7.	Karnataka	975	36.55	6.40
8.	Odisha	875	24.38	5.74
9.	Tamil Nadu	830	28.81	5.44
10.	Madhya Pradesh	825	19.49	5.41
11.	Chhattisgarh	800	68.90	4.25
12.	Punjab	675	18.76	4.43
13.	Gujarat	495	16.52	3.25
	Total	15.230	29.24	100.00

Source: Statistical Abstracts of India 2003.

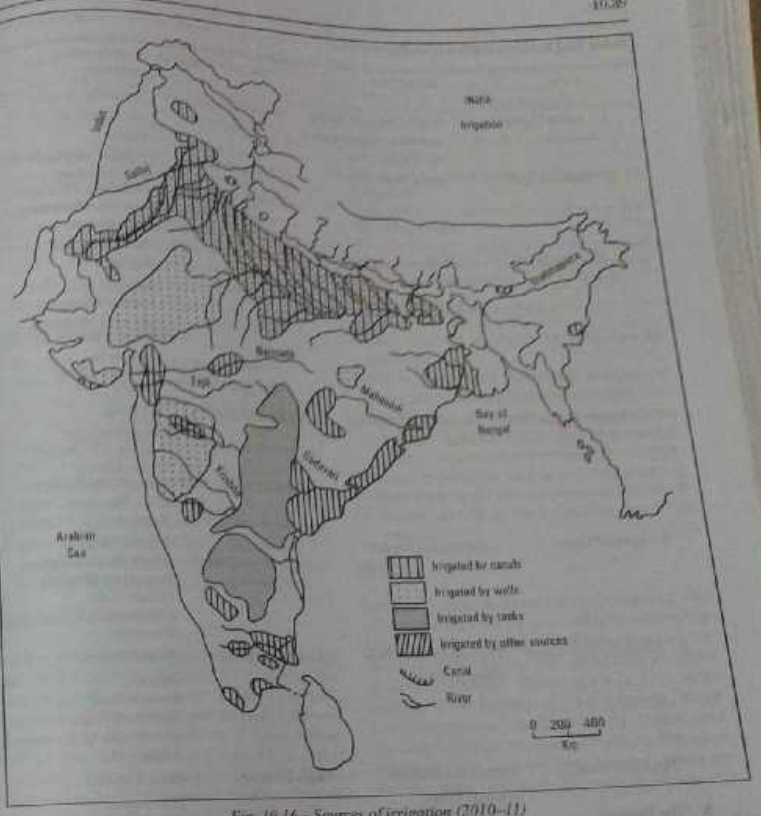

Fig. 10.16 – Sources of irrigation (2010–11)

Table 10.21: Major Canals of India

	Canal	Source/Year	Area under Command	Distrits under Irrigation
1.	Indira Gandhi Canal	Harike Barrage (Satluj and Beas rivers) started 31st March, 1958	8.6 million hectares	Rajasthan. It does not irrigate in Punjab.
2.	Bhakra Canal	Satluj River, 1954	1.5 million hectares	Punjab, Haryana and Rajasthan, Ludhiana, Patiala, Sangrur, Jalandhar, and Firozpur
3.	Sharda Canal	Banbasa, near India-Nepal border. Opened in 1928	8 lakh hectares	Bareilly, Kheri, Pilibhit, Shahjahanpur, Hardoi, Lucknow, Unnao, Pratapgarh, Sitapur, Sultanpur, Barabanki, Allahabad, Rai-Bareilly
4.	Upper Ganga Canal	Kankhal (Hardwar), 1954	7 lakh hectares	Hardwar, Muzaffarnagar, Meerut, Ghaziabad, Bulandshahr, Aligarh, Mathura, Etah, Mainpuri, Kanpur
5.	Sirhind Canal	Rupnagar (Ropar)	7 lakh hectares	Patiala, Sangrur, Bhatinda, Ludhiana, Ferozepur (Punjab), Hissar, Sirsa, Fatehabad (Haryana)
6.	Lower Ganga Canal	Narora (Bulandshahr District), 1878	4.6 lakh hectares	Bulandshahr, Aligarh, Farrukhabad, Mainpuri, Etah, Etawah, Kanpur, Allahabad
7.	Bist Doab Canal	Part of the Bhakra-Nangal Project	7 lakh hectares	Jalandhar and Hoshiarpur
8.	The Western Yamuna Canal	Tajewala (Feroz Tughlaq)	4 lakh hectares	Ambala, Kurukshetra, Karnal, Panipat, Rohtak, Hissar, Sirsa, Faridabad, and Jind
9.	Upper Bari-Doab Canal	Madhopur (Pathankot), Ravi-River, 1859	3.5 lakh hectares	Gurdaspur and Amritsar

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10. Tawa Canal	Tawa Barrage	3 lakh hectares	Hoshingabad
11. Eastern Yamuna Canal	Faizabad (Saharanpur), 1831	2 lakh hectares	Saharanpur, Muzaffarnagar, Meerut, Baghpat, Ghaziabad
12. Mettur Canal	Metture Dam	1.2 lakh hectares	Salem, Tiruchirapalli

Merits of Canal Irrigation

1. Canals are a perennial source of irrigation.
2. Canals are a cheap source of irrigation.
3. Canals carry a lot of sediments which enrich the fertility of the irrigated fields.
4. Canals make agriculture sustainable.
5. Canals help in the control of floods during the rainy season.

Demerits of Canal Irrigation

1. Overuse and misuse of canal water.
2. Over irrigation leads to water logging.
3. Excessive irrigation leads to rise in underground water table.
4. Many canals over flow during the rainy season.
5. Canal irrigation is possible only in the plain areas.
6. Water-logged areas become the breeding grounds for mosquitoes.
7. In the semi-arid areas canal irrigation lead to the problem of *usar (kallar)* formation.

Wells and Tubewells

Wells and tubewells irrigate the largest cropped area of the country. About 54 per cent of the total irrigated area is under tubewell and well irrigation. Tubewell irrigation is extensively developed in Northern Plains of India. About 95% of the tubewells are located in Uttar Pradesh, Punjab, Haryana, Gujarat, Bihar, Madhya Pradesh, Maharshtra, Andhra Pradesh, Karnataka, West Bengal and Odisha.

Merits of Tubewell Irrigation

1. Tubewells can be installed in a short period of time.
2. Tubewells can be installed at convenient places by the government and farmers.
3. Tubewells can be installed at low cost.
4. Tubewell is an independent source of irrigation.
5. Tubewells can be used as and when the necessity arises.
6. The tubewell water contains several minerals and salts (e.g. nitrate, sulphate, etc) which enhance the fertility of soil.

Demerits of Tubewell Irrigation

1. Only limited area can be irrigated by tubewells.
2. The underground watertable diminishes, especially during the summer season.
3. In the case of failure of monsoon, the underground watertable falls and enough water is not available for irrigation of crops.
4. Since tubewells and pumping sets are operated with electricity and diesel, it is considered as an expensive mode of irrigation.

Tanks

Tank irrigation is generally practiced in the eastern part of the Deccan Plateau where the topography is suitable for erecting dams across small rivulets and for the collection of water in artificial lakes.

Tanks are found in large number in the districts of Chengalpattu, North Arcot, South Arcot in Tamil Nadu, Nellore and Warangal districts in Andhra Pradesh. The other states where it is prevalent to lesser extent are Odisha, West Bengal, Uttar Pradesh, Karnataka and Maharashtra.

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Drip Irrigation

In this method the application of water is precise but slow as discrete drops, continuous drops, tiny streams of miniature sprays through mechanical devices. Drip irrigation has the advantages of water saving and more suitable to poor soils, no soil erosion and improves the efficiency of fertilizers.

Irrigation Potential

With sustained and systematic development, irrigation potential has increased from 22.6 million hectares in 1951 to 87.8 million hectares in 2010. Since April 1978, irrigation projects have been classified on the basis of their command area:

Major: More than 10,000 hectares
Medium: 2000-10,000 hectares
Minor: Less than 2000 hectares.

Minor irrigation projects are widely distributed and they provide instant and reliable sources of irrigation to the farmers. Ground water development which forms bulk of the minor irrigation programme is implemented primarily through the individual and co-operative efforts. According to a recent study conducted by the World Bank about 20% of the 40 million hectare of irrigated agricultural land in India is reported to suffer from a water-logging and salinity problem which have reduced the yield of crops substantially.

Expansion of irrigation facilities, along with consolidation of the existing systems, has been the main part of the core strategy for increasing production of food with sustainable and systematic development of irrigation gains.

The irrigation potential through major, medium and minor irrigation projects has increased from 22.6 million hectares (mha) in 1951 to 103 mha at the end of the tenth plan.

National Water Resource Policy-2002

The National Water Resource Policy, 2002 lays emphasis on the integrated water resources development and management. The main points of this policy are:

1. Optimal and sustainable utilisation of the available surface and ground water.
2. Creation of well developed information system.
3. Water conservation and demand management.
4. Quantity and quality aspects as well as environmental consideration.
5. Involvement of beneficiaries and stakeholders in the project of planning and participatory approach in water resources management.
6. Adequate training and research.
7. Resettlement and rehabilitation aspect of project affected persons.
8. The policy encourages the Private Sector Participation in placing development and management of water resources projects for diverse uses, wherever feasible with a view to introducing innovative ideas generating financial resources.
9. Introducing corporate management and improving service efficiency and judicious distribution.
10. Introducing accountability of the water users.

Table 10.22: India–General Land Use, 2005-06

	Land Category	Area (million hectares)	Percentage of the Total Geographical Area
1.	Total geographical area	328.75	
2.	Total reporting area for land use	306.25	93.20
3.	Area under forests	69.00	22.55
4.	Area not available for cultivation		
	(i) Area put to non-agricultural uses	23.25	7.61
	(ii) Barren and uncultivable land	19.18	6.25

	(b) Land under tree crops and groves	3.62	1.18
	(c) Culturable waste	13.83	4.52
6.	Fallow land		
	(i) Current fallow	14.80	4.83
	(ii) Other fallow	10.11	3.30
7.	Net sown area	141.23	46.15
8.	Area sown more than once	48.51	32.60
9.	Total or gross cropped area	189.74	
10.	Area under irrigation	78.00	55.30

Source: Statistical Abstracts of India, 2005-06.

***Table 10.23:** Size of Holdings*

	Category of Holding	*Area (hectares)*	*Percentage of Holdings*
1.	Marginal	Below one	50.6
2.	Small	1-2	20.0
3.	Semi-medium	2-4	15.2
4.	Medium	4-10	11.3
5.	Large	Above 10	04.0

Source: Statistical Abstracts of India, 2005-06.

***Table 10.24:** Average Size of Holdings in Selected States of India*

	State	*Size of Holdings*
1.	Rajasthan	4.00
2.	Punjab	3.45
3.	Gujarat	2.85
4.	Madhya Pradesh	2.75
5.	Haryana	2.45
6.	Maharashtra	2.40
7.	Karnataka	2.15
8.	Andhra Pradesh	1.50
9.	Odisha	1.30
10.	Himachal Pradesh	1.15
11.	Assam	1.15
12.	Tamil Nadu	1.00
13.	West Bengal	0.80
14.	Jammu & Kashmir	0.75
15.	Uttar Pradesh	0.72
16.	Bihar	0.70
17.	Kerala	0.30
India		**1.50**

Source: Statistical Abstracts of India-2005-06.

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Table10.25: *Cropping Seasons in India*

Cropping Season	Major Crops Cultivated in Northern States	Major Crops Cultivated in Southern States
Kharif (June-September)	Rice, cotton, bajra, maize, jowar, tur, black-gram, green gram.	Rice, maize, ragi, jowar, groundnut
Rabi (October-March/April)	Wheat, gram, barley, mustard, rapeseed, lentil (masoor), peas, green-fodder (Barseem)	Rice, maize, ragi, groundnut, jowar
Zaid (April-June)	Vegetables, cucumber, melons, fodder	Rice, vegetables, fodder

Dryland Farming

Dry-land farming is the cultivation of crops in areas where the source of water to crops is only rainfall and the average annual rainfall varies between 40 -70 cm. and the annual variability of rainfall is between 20 to 60 per cent. According to the experts of agriculture, this amount of rainfall is sufficient to grow a number of crops, but its distribution is very erratic and most of the time precipitation is less than the rate of evapotranspiration. In fact, more than 80 per cent of the rainfall is recorded in only 10-15 days. In India about 62 per cent of the net cultivated area is under dry-land and rain-fed cultivation which contribute about 40 per cent of the total production of India. The salient features of dry-land farming and rain-fed agriculture has been given in **Table-10.26**

Table10.26: *Dry-land and Rain-fed Agriculture*

Salient Features	Dry-land Cultivation	Rain-fed Cultivation
1. Rainfall	<70 cm	> 70 cm
2. Moisture availability to crop	shortage	Adequate
3. Growing season	< 200 days	>200 days
4. Cropping system	Single crop or intercropping	Inter-cropping or double–cropping
5 Constraints	Wind and water erosion	Water erosion
6. Regions	Arid and semi-arid as well as upland of sub-humid/humid regions	Humid and sub-humid regions

The area under irrigated and rain-fed conditions has been given in **Table-10.27**

Table10.27: *Area under irrigated and rain-fed conditions in India*

Class	Area (in million ha)	Percentage of total arable land
Total arable	143.8	100.00
Dry-land	54.9	24.6
rain-fed*	65.5	45.5
Irrigated	43.6	30.5

*Includes flood prone area of 15 million hectares

Problems of Crop Production in Dry-land Farming: Following are the main problems of dry-farming cultivation. Consequently, crop failures are quite common.

1. **Inadequate and Uneven Distribution of Rainfall:** As stated above, the rainfall in the dry-farming areas is low and highly variable which results in uncertain crop yields.
2. **Late Onset and Early Cessation of Rains:** When the arrival of summer monsoon is late, the sowings of crops are delayed resulting in poor yields. Times, the rains may cease very early in the season exposing the crop to drought during flowering and maturity stages which reduces the crop yields considerably.
3. **Prolonged Dry Spells During the Crop Period:** Long breaks in the rainy season is an important feature of Indian Monsoon. These intervening dry spells when prolonged during crop period reduces crop growth and yield and when unduly prolonged, crops fail.
4. **Low Moisture Retention Capacity:** The crops raised on coarse textured soils like sandy or red soil. Loss of rain water occurs as runoff due to undulating land and shallow soils.
5. **Low Fertility of Soils:** Dry land are not only thirsty, but hungry too. Soil fertility has to be increased, but there is limited scope for extensive use of chemical fertilizers due to lack of adequate soil moisture.

Strategy for Sustainable Dry Farming

In the dry land farming the yield of crops per unit area is low. In order to enhance the crop yield, the important drought management practices include selection of suitable crops and cropping systems, tillage, seeds and sowing, nutrient management, rain-water management, weed management, pest management and harvesting and storage.

(i) **Moisture Conservation:** Moisture conservation is the key of successful crop production in dry-land areas. Deep and repeated ploughing and pulverization of soil enables preservation of a large amount of moisture, uniform soil structure, enhanced root growth and extraction of soil moisture from deeper soil layers.

(ii) **Choice of Crops:** Short duration crops and varieties with deep rooted system and drought tolerance are better adapted to dry-land farming. Among the cereals barley has better moisture extraction power than wheat.

(iii) **Early Sowing:** Early sowing of crops is advisable as it helps in (i) better moisture conservation, (ii) longer growing season and avoidance of pests and diseases.

(iv) **Optimum Plant Population:** Maintenance of optimum plant population is a must for getting good results. The plant population for the rabi (Winter season) should be less as compared to that of the kharif (Summer Season) crops.

(v) **Intercropping**: In areas of dry land farming inter-cropping is being recommended and practiced. In such areas, at least one of the component crops succeeds in drought years and there is every chance to get two crops in good rainfall years. The different intercropping systems are followed in different regions of the country based soil, rainfall, market price and marketing facilities. Intercropping systems are subject to change due to change in market price of component crops. The dominant intercropping systems are: (i) groundnut +pigeon-pea, (ii) sorghum +pigeon-pea, (iii) groundnut +castor, (iv) finger-millet +pigeon-pea, (v) wheat + gram, (vii) cotton + gram, (viii) millets + black-gram, (ix) pearl-millet+ green gram, etc.

(vi) **Nutrient Management**: Rain-fed soils are more deficient than irrigated soils in nutrient because of their poor organic matter status. According to the experts of agriculture, compared to all other nutrients, response of crops to N fertilizers has been maximum.

(vii) **Weed Management**: Weed density is generally low under dry land conditions than under irrigated condition. Several generations of weeds occur under irrigated conditions due to continuous availability of water. Limited number of generation of weeds occurs due to shorter period of water availability. However, weed management is equally important under dry land conditions as weeds compete for soil moisture. Weed if not properly controlled can take away as much as 30 per cent moisture and nutrients leading to substantial reduction in yields.

(viii) **Pest Management**: Important pests on crops are weather bound and they can be avoided through proper scheduling of their sowing time. Early sowing facilitates vigorous seedling growth which can withstand the adverse effects of pests.

(ix) **Water Harvesting**: Water harvesting can be defined as collection and conservation of excess rain water directly in-situ or in construction reservoir for the use of crop production.

(x) **Integrated Dry Land Technology**: The application of single technology to dry region is generally incapable of giving desired results. The adaptation of all related technologies as an integrated dry land technology can provide a synergistic effect and can improve the productivity in dry farming regions.

(xi) **Mulches**: About 60 to 75 per cent of the rainfall is lost through evaporation. These evaporations can be reduced by applying mulches. Mulch is any material applied on the soil surface to check evaporation and improve soil water. Application of mulches results in additional benefits like soil conservation, moderation of temperature, reduction in soil fertility, weed control and improvement of soil structure.

The mulches may be of different types as (i) soil-mulch or dust-mulch, (ii) stubble mulch, (iii)straw-mulch, and vertical mulching-breaking of hard pans to improve root penetration and water percolation.

(xi) **Selection of Proper Crop Varieties for Dry-land Farming**: In the dry farming regions, crops have to be selected with suitable crop duration to coincide with the length of the growing season. However, if the monsoon turns to be extra-ordinary good, opportunity is lost if only short duration crops are sown. Farmers with economic strength and motivation for high profits with some amount of risk can go for crops of long duration. The long duration crops with flexibility are more suitable. For example, pearl-millet and sorghum can be rationed if monsoon extends. Sunflower can be introduced for higher profits with certain amount of risk.A crop or variety intended for dry land farming should have (a) deep and extensive root system, thereby a better moisture extraction capacity, (b) low transpiration rate and (c)shorter duration of growth. Some recommended varieties of crops for dryland farming are as under:

Jowar (millets)	CSH1, CSH-2, CSH4
Bajra (Pearl –millet)	HB-1,HB-3, NHB-5,
Wheat	C-306, K-65, K-68
Barley	Jyoti, Karan -4, Karan-15, Karan-19
Moong (Green-gram)	T-44, Jawahar-45
Urad (Black gram)	T-9, Mash-2
Gram	RS-10, T-1, T-3
Mustard	Pusa-Barani

Rajora, R., 1988, Integrated Watershed Management, Jaipur, Rajasri Publications.

Sankara Reddy, G.H. and T. Yellamanda Reddy, Principles of Agronomy, Kalyani Publishers.

Contract Farming

Contract farming is a method of farming based on the optimisation of profit from agriculture. In the contract farming a company enters into a written contract with the farmer/farmers with the following objectives:

(i) To produce a given volume of product of specified quality. The product will be purchased by the company on an agreed price. In other words, marketing enters into contract with production. The company after making the purchase, freezes, dehydrates and starts canning operation. Sometimes the company enters into contracts with the co-operative societies.

(ii) In contract farming the main crops grown are vegetables, fruits, flowers and poultry.

Merits of Contract Farming

The farmers gain certain advantages, given below:

(i) The sale of their products is assured.

(ii) They earn higher price than the price in the open market.

(iii) The capital requirements of the farmers are reduced as the contract often agreed for advance payment.

(iv) Very often the companies also provide specialised knowledge and expertise.

Demerits of Contract Farming

(i) If a farmer has produced quality product, he may get a higher price in the open market than that offered by the contract.

(ii) The farmer acts mechanically and loses his independent status.

(iii) The bargaining power is tilted in favour of companies as financially they are more powerful.

(iv) The farmer becomes an economic man which may not be in accordance to his traditional mode of life. In fact, Indian farmers are generally practice agriculture for satisfaction as a mode of life.

Natural Hazards

A hazard is an unexpected threat to humans and/or their property. By this definition, the Indian monsoon is not a hazard, but its failure is. The most frequent occurring hazards are climatic (i) drought, floods, cyclones, ice, snow, and fog, (ii) tectonic: earthquakes, volcanoes, and tsunami, (iii) mass movement: land slides, land creep, rock-fall, and avalanches.

Some geographers distinguish between environmental hazards, but others stress that human activity plays a part in the development of most hazards. Some of the important natural hazards which create havoc in India have been described briefly in the following:

Drought

Drought has been defined differently by different geographers. A long, continuous period of dry weather is known as drought. The Meteorological Department of India defined drought as a period of at least 22 consecutive days recording less than 0.25 cm of rainfall. This definition however, does not apply to the whole of India. In areas like Mawsynram and Cherrapunji (1187 cm) even one week recording less than 0.25 mm may be considered as a drought period. In India drought is often associated with the failure of monsoon, especially in the years of El-Nino like that of 1982, 1998, and 2009. In a drought year, the vegetation, crops, and surface and underground water tables are adversely

affected. An agricultural drought is a period of four consecutive weeks with half or less than half of the normal rainfall or with a weekly rainfall of 5 cm or less during the period from mid-May to mid-October, when about 80 per cent of country's sowing area is under *kharif* crops. On an average, one in every five years is a drought year in India, while in western Rajasthan every two out of five years are drought years. The drought prone areas of India have been shown in Fig. 10.17 and discussed below:

1. **The Arid and Semi-arid Areas of Rajasthan**. There is a contiguous region covering Thar Desert, northern parts of Gujarat, south-western parts of Haryana and Punjab and parts of the Agra Division of Uttar Pradesh which is drought prone area of India. The average annual rainfall in this region varies between 15 and 25 cm and the variability of rainfall between 20 to 60 per cent.
2. **The Rainshadow Areas of Western Ghats**. This is the area lying to the east of the Western Ghats, covering the greater parts of Maharashtra, northern parts of Andhra Pradesh, Karnataka, and Tamil Nadu. The average annual rainfall in this region is also less than 75 cm, while the variability of rainfall is more than 30 per cent.
3. **Other Drought Prone Areas**. There are isolated tracts in Odisha, Purulia district of West Bengal, parts of Jharkhand, Chhattisgarh, Baghelkhand (Madhya Pradesh), Bundelkhand (Uttar Pradesh), Ladakh (J&K), and Madurai and Coimbatore (Tamil Nadu) which are often adversely affected by droughts.

Some of the important droughts in India occurred during the recent years are given below:

1963 - 64 – Bihar and West Bengal
1965 - 66 – Maharashtra
1966 - 67 – Odisha
1982 - 83 – Haryana and Rajasthan
1987 - 88 – Rajasthan and Gujarat
1999 - 97 – Bolangir and Kalahandi (Odisha)
2009 – Greater parts of India

Drought Management

The Government of India has paid enough attention to the drought affected areas. Prior to 1987, the government used to provide relief to the drought affected people by providing employment and distribution of food-grains through Public Distribution System (PDS). The consequent drought relief expenditure imposed a serious strain on public finances as huge amounts had to be diverted from development for undertaking relief projects. In some states like Rajasthan, the drought relief outlay exceeded the developmental outlays. Now, the drought relief approach has been adopted in which emphasis is given to water conservation and rain water harvesting.

Floods

A high water level along a river channel or on a coast that leads to inundation of land which is not normally submerged. River floods which involve inundation of the floodplain may be caused by: (i) precipitation, (ii) collapse of dams, (iii) drainage of ice-dammed lakes, (iv) high tides, and (v) storm surges.

In India, due to erratic and heavy seasonal rainfall during the monsoon months many of the areas are adversely affected by floods. The intensity of floods, however, varies from region to region and month to month. The National Flood Commission of India has estimated that about 40 million hectare of land (1/8 of the geographical area) of the country, is prone to recurring floods. Along with heavy drainage, the Ganga-Brahmaputra drainage system brings down large volume of sediments that cause aggradation of river beds and seasonal overflows. Crops and other properties in the flood plain suffer heavy damages. An annual flood is a serious problem in some parts of the country, particularly in Andhra Pradesh, Assam, Bihar, Gujarat, Odisha, Tamil Nadu, Uttar Pradesh and West Bengal. It is estimated that losses from the annual floods amount to Rs. 2305 million, causing suffering to 50 million people, affecting 10 million hectares of cropped land.

Cyclones (Tropical)

Tropical cyclones occurring in the of Bay Bengal and the Arabian Sea are natural hazards. They

Fig. 10.17 - Drought prone areas (1950- 2010)

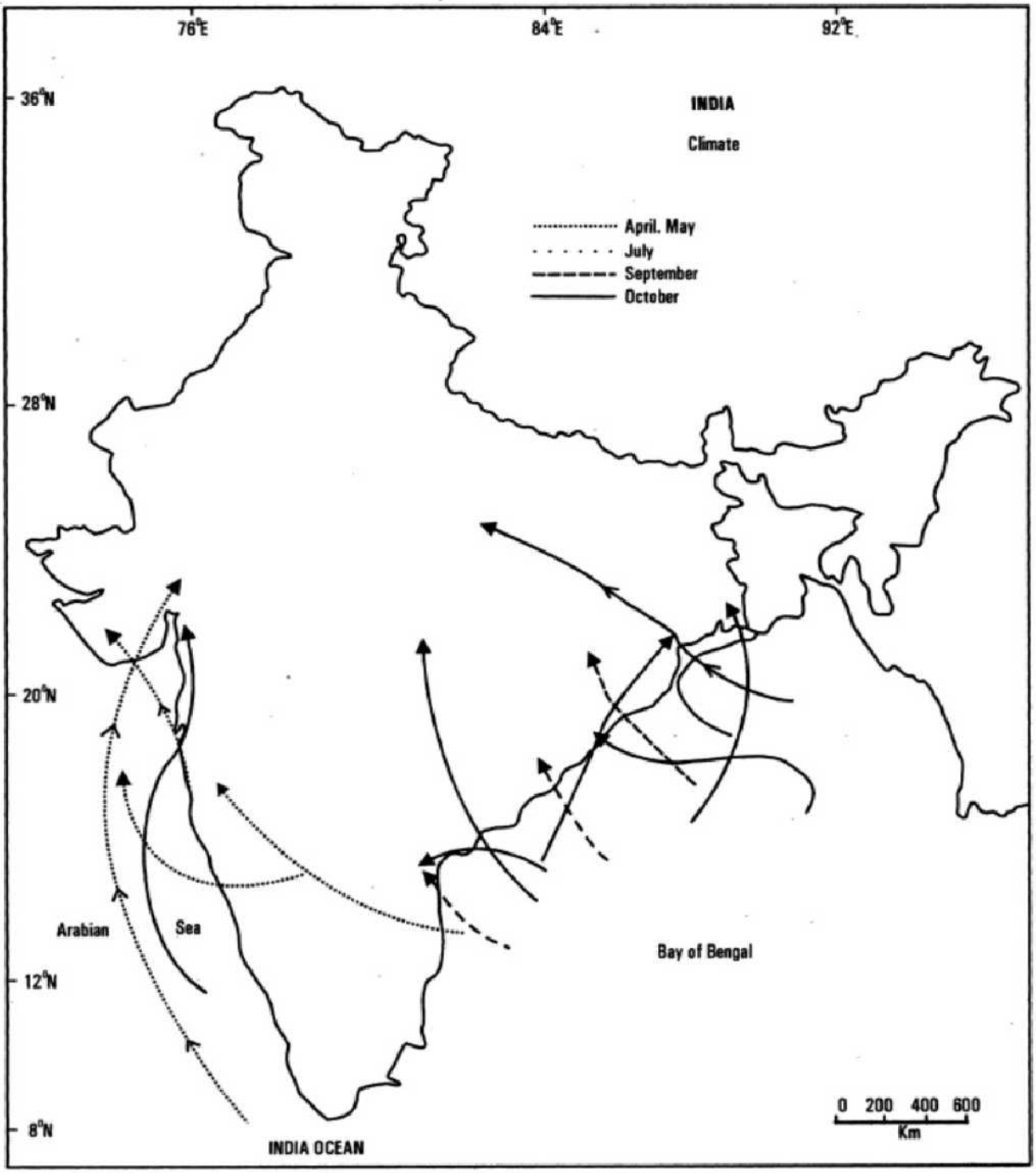

Fig. 10.18 – Cyclones

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Power Resources

The socio-economic development of a country is largely controlled by the availability of power and energy resources. The main power resources of India are coal, petroleum, natural gas, and electricity. In recent years, the development of nonconventional sources of energy is getting increasing attention of the planners. Generation of nuclear power is being geared up to contribute significantly to the over-all availability of energy.

Electricity

Electricity is a clean source of energy. It is generated from water, coal, mineral oil, natural gas, wind, sea-waves, tides, thermal springs, and atomic minerals. Electricity is relatively cheap, transportable, pollution free, and renewable. Because of these advantages it is becoming increasingly popular.

The per capita consumption of electricity is often considered as an indicator of socio-economic development. In India, the per capita consumption of electricity is about 350 kWh which is much below the per capita consumption in the world, i.e. 1000 kWh and USA 7000 kWh.

The total installed capacity of electricity by different sources was only 2.3 thousand MW in 1950-51 which rose to 150 thousand in 2005-06. The highest installed capacity is that of thermal power, accounting for 63 per cent of the installed capacity.

***Table 10.28**: India–Installed Capacity of Electricity (in thousand MW)*

Year	*Hydro*	*Thermal*	*Nuclear*	*Others*	*Grand Total*
1950-51	0.6	1.1	-	0.6	2.3
1960-61	1.9	2.7	-	1.0	5.6
1970-71	6.4	8.0	0.4	1.6	16.3
1980-81	11.8	17.6	0.9	3.1	33.3
1990.91	18.8	45.8	1.5	8.6	74.7
2000.01	25.0	76.0	2.9	15.2	119.1
2005.06	35.0	95.0	2.8	17.2	150.0

Source: The Economic Survey, 2006-07.

Coal: The major coal deposits of India have been shown in **Fig. 10.20.**

***Table 10.29**: Coal Deposits in India (Statewise)*

State	*Total Deposits (million tonnes)*	*Percentage of the Total Coal Deposits*
1. Jharkhand	72,565	28.93
2. Odisha	61,684	24.59
3. Chhattisgarh	40,865	17.09
4. West Bengal	27,495	10.96
5. Madhya Pradesh	19,672	7.34
6. Andhra Pradesh	17,595	7.02
7. Maharashtra	8,635	3.44
8. Uttar Pradesh	1135	0.45
9. Meghalaya	469	0.20
9. Assam	385	0.15

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10. Bihar	178	0.07
11. Arunachal Pradesh	95	0.02
12. Nagaland	22	0.01
Total	**250,795**	**100.00**

Source: Statistical Abstracts of India, 2006-2007.

Petroleum

Petroleun is an important source of energy. Crude oil is obtained from the sedimentary rocks. The statewise production of petroleum has been shown in **Fig. 10.21 (Table 10.30).**

***Table 10.30:** Crude Oil Production in India*

State/Region	*Production (thousand tonnes)*	*Percentage to the Total Production*
1. Mumbai High	22.10	65.00
2. Gujarat	06.00	17.65
3. Assam	05.10	15.00
4. Andhra Pradesh	00.39	1.15
5. Tamil Nadu	00.37	1.10
6. Arunachal Pradesh	00.04	0.10
Total (All India)	**34.00**	**100.00**

Source: Statistical Abstracts of India 2007.

Natural Gas

Natural gas is obtained from the oil-wells. Being lighter, it overlies the oil pool and is required to be taken out first at the time of drilling oil-well. Natural gas is mainly utilised in the manufacturing of chemical fertilizers, thermal power plants, heating of industries and fuel (cooking gas).

The exploration of natural gas is being done by the Oil and Natural Gas Commission. According to one estimate, India has a total natural gas reserve of about 450 billion cubic meters. Out of the total reserves, about 75 per cent lies in the Bassein and Bombay High, about 12 percent in Gujarat, 7 per cent in Andhra Pradesh and 6 percent in Assam. Natural gas is also found in the Barmer and Jaisalmer Districts of Rajasthan, Kangra Districts of Himachal Pradesh, and Firozepur District of Punjab. The trend of natural gas production has been shown in **Table 10.31.**

***Table 10.31:** India–Trend in Natural Gas Production (2009)*

Year	*Production (million cubic meters)*
1960-61	17
1970-71	76
1980-81	200
1990-91	12,870
2000-01	20,920
2005-06	25,750

Source: Statistical Abstracts, India, *2006-07.*

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(2 cm) of rainfall may fall in a few minutes. At the occurrence of a cloudburst loss of property and human life is frequent which may take the shape of disaster and catastrophe. The Uttarakhand cloudburst on 16th June, 2013 is an example of large scale destruction of human life and economic structure.

Because of the amount of rainfall involved, a cloudburst can be quite dangerous, especially if it persists for several hours. Flashflood is common with cloudburst, and in areas with arroyos, and gullies are quickly filled with water, sweeping away any people and animals which might be in the region. Flooding can also render streets unusable, and in extreme cases it can shut down entire city (like Kedarnath, Rambara, Gaurikund, etc.) as people struggle to cope with the influx of water. The Uttarakhand cloudburst known as Himalayan Tsunami of 16th June, 2013 is an example of one of the worst cloudburst disasters in the recent history of India.

Often, these rainstorms appear in the summer season. In the farming communities, they are sometimes welcomed, as a cloudburst can irrigate the withering crops very thoroughly. Most people try to avoid being caught out in the weather. Drowning have also been linked with cloudbursts, even without widespread flooding, because people can become disoriented when caught outside in severe weather. The extremes of rainfall in cloudbursts have been given in the Table 10.30.

Table 10.30: *Extremes of Rainfall in Cloudbursts*

Duration	Rainfall	Location	Date
1 minute	38.10 mm (1.5 inches)	Basse-Terre, Guadeloupe (West Indies)	26 November, 1970
15 minutes	199.12 mm (7.9 inches)	Plumb Point, Jamaica	12th May, 1916
1 hour	250 mm (9.84 inches)	Leh, Ladakh, India	August 6, 2010
10 hours	940 mm (37 inches)	Mumbai, India	July 26, 2005
20 hours	2329 mm (91.69 inches)	Ganges Delta, India	January, 1966

In the Indian subcontinent, a cloudburst usually occurs when a moisture laden monsoon cloud drifts northward, from the Bay of Bengal or Arabian Sea across the plains, then on to the Himalaya and bursts, bringing rainfall as high as 75 millimeters per hour.

Table 10.31: *Cloudburst Damage in India in recent post.*

Year	Place of cloudburst	Deaths
August, 1998	Gowalpara (Assam)	400
July, 1970	Alaknanda Basin (Uttarakhand)	500
15th August, 1997	Chirgaon-Shimla District (H.P.)	115
August, 17, 1998	Milpa Village, Kumaun Division (Uttarakhand)	250
July 26, 2004	Mumbai cloudburst	>5000
August 6, 2010	Leh-Ladakh (J &K)	>1000
June 16, 2013	Kedarnath cloudburst (Uttarakhand)	Several thousands

Cloudburst in Uttarakhand

Uttarakhand the 'abode of gods' with its magnificent snow-covered peaks, prestinus forests and awe inspiring rivers is a sacred place in Indian culture. Millions of pilgrims and tourists visit the state of Uttarakhand every year, especially during the summer season. Despite all these attractions, the state of Uttarakhand has a highly vulnerable ecosphere. There are sudden cloudburst, flashfloods, landslides, rock-fall, soil-creep and mass-wasting. The cloudburst of 16th June, 2013 has been termed by the experts as the 'Himalayan Tsunami' (Fig.10.19-a).

The pace at which snow melt moves can be affected by the volume of rain and ground conditions. As the turbulent rivers of Uttarakhand moved downwards on steep slopes, they carried more weathered material and the water gained speed and volume, rapidly increasing the levels downstream. It led to the flash flood and became an unparalleled disaster in the modern history of the state. In the words of a poet "Tabahi ka Manzar Dukhon ki Kahani: Pahadon pe Barsa Pahadon ka Pani".

This cloudburst resulted into enormous loss of life, property and infrastructure. With National Highways damaged at several places, bridges washed away, electricity and phone networks down, hotels and motels destroyed, towns and rural settlements buried and numerous ravaged places marooned. The Uttarakhand cloudburst

Fig. 10. 19-a Cloudburst Region of Uttarakhand (16th June, 2013)

affected about 48,000 sq km of Bhagirathi, Alaknanda rivers and their tributaries. The worst affected was the Mandakni River Basin in which the Kedarnath-shacine, Rambara, Caunkund and Guptkashi towns were devastated. According to official figures, the number of villages affected by the flash flood was 3978, roads damaged 1636 km, worth Rs. 500 crore; cost of resorting drinking water network RS.100 crore; damage to hydro-power projects about 150-200 crore.

According to the experts of environment, ecology the disaster might have been waiting to happen. The illegal constructions on the hills, the exponential growth of rickety structures that serve as hotels which are sordidly maintained, the lackadaisical attitude towards warning the natural catastrophes are largely responsible for the disaster of Uttarakhand. In fact the disaster was man made. The main anthropogenic causes of disaster are given below:

1. The development and extension of roads and the National Highways NH-58-Maria Pass, NH-108-Gangotri-Angar, NH-109-Guptkashi-Kedarnath, etc have disturbed the ecology and the highly fragile ecosystems of the region.
2. Heavy pressure of cultural activities and tourists: To accommodate the tourists, there is tremendous growth of urban settlements, hotels, hill resorts, camping-sites and business-houses in the vulnerable hilly areas.
3. Deforestation: Large scale deforestation has taken place in the young folded mountains of the lesser and outer Siwaliks.
4. Construction of dams and multi-purpose projects: Several projects in the form of Tehri Dam, Koteswar, dam, Maneri-Bhali Hydel Project, Loharinge-Pala Hydel Project, Srinagar Project, Asi-Ganga Project and Vishnu-Prayag Project. The reservoirs of these projects have disturbed the isostatic equilibrium in the Himalayan region leading to frequent earthquakes and landslides.
5. The ambitious plan of the government of Uttarakhand to convert the state into 'Urja-Pradesh' (Energy Province), and the leading 'tourist region' of India.

Cloudburst Management

Cloudburst is a natural disaster that cause great damage to life and property. Some of the steps that can help in reducing the damage to life and property in the affected areas are given below:

1. Based on scientific data, there should be delineation of eco-sensitive zones.
2. The maximum and minimum discharge of water of all the rivers and their tributaries should be ascertained and the people should be made aware about the possible discharge of the rivers.
3. Better and effective system of weather forecasting and dissemination of weather related information are imperative to mitigate the disasters like cloudburst.
4. There should be proper site selection and planning of the rural and urban settlements.
5. There is an urgent need for a comprehensive renewal and relook at construction techniques of roads, houses, factories and other structures.
6. Blasting of rocks for the construction of roads should be stopped or minimized.
7. There should be strict regulation of tourism.
8. Uncontrolled traffic jams and increased environmental pollution play havoc in the fragile ecosystems of the Himalayas. They should be checked and mitigated.
9. Human resource required to tackle the natural disaster should be strengthened.
10. The post-cloud-burst operations include quick action to rescue of stranded people buried under thick cover of debris to evacuate them to safer places. Immediate medical help be provided to survivors.
11. The Sant Samaj (religious community) should work as a pressure group to check the construction of multi-story buildings, hotels, Dharamsalas and Sarais.
12. The state government should take strict and effective action against the encroachment around the shrines in the form of make shift shops, Dhabas and temporary shelters.

If these steps are taken together, the consequent damage to life and property, infrastructure, ecology and environment can be reduced substantially.

Power Resources

The socio-economic development of a country is largely controlled by the availability of power and energy resources. The main power resources of India are coal, petroleum, natural gas, and electricity. In recent years, the development of nonconventional sources of energy is getting increasing attention of the planners. Generation of nuclear power is being geared up to contribute significantly to the over-all availability of energy.

Electricity

Electricity is a clean source of energy. It is generated from water, coal, mineral oil, natural gas, wind, sea-waves, tides, thermal springs, and atomic minerals. Electricity is relatively cheap, transportable, pollution free, and renewable. Because of these advantages it is becoming increasingly popular.

The per capita consumption of electricity is often considered as an indicator of socio-economic development. In India, the per capita consumption of electricity is about 350 kWh which is much below the per capita consumption in the world, i.e. 1600 kWh and USA 7000 kWh.

The total installed capacity of electricity by different sources was only 2.3 thousand MW in 1950-51 which rose to 150 thousand in 2005-06. The highest installed capacity is that of thermal power, accounting for 63 per cent of the installed capacity.

Table 10.32: India–Installed Capacity of Electricity (in thousand MW)

Year	Hydro	Thermal	Nuclear	Others	Grand Total
1950-51	0.6	1.1	-	0.6	2.3
1960-61	1.9	2.7	-	1.0	5.6
1970-71	6.4	8.0	0.4	1.6	16.3
1980-81	11.8	17.6	0.9	3.1	33.5
1990-91	18.8	45.8	1.5	8.6	74.7
2000-01	25.0	76.0	2.9	15.2	129.1
2005-06	35.0	95.0	2.8	17.2	150.0

Source: The Economic Survey, 2006-07.

Coal. The major coal deposits of India have been shown in **Fig. 10.20.**

Table 10.33: Coal Deposits in India (Statewise)

State	Total Deposits (million tonnes)	Percentage of the Total Coal Deposits
1. Jharkhand	72,565	28.99
2. Odisha	61,684	24.59
3. Chhattisgarh	40,865	17.09
4. West Bengal	27,495	10.96
5. Madhya Pradesh	19,672	7.34
6. Andhra Pradesh	17,595	7.02
7. Maharashtra	8,655	3.44
8. Uttar Pradesh	1135	0.45
9. Meghalaya	469	0.20
9. Assam	385	0.15
10. Bihar	179	0.07

11. Arunachal Pradesh	95	0.02
12. Nagaland	22	0.01
Total	**250.788**	**100.00**

Source: Statistical Abstracts of India 2006-2007.

Petroleum

Petroleum is an important source of energy. Crude oil is obtained from the sedimentary rocks. The statewise production of petroleum has been shown in **Fig. 10.21 (Table 10.34)**.

Table 10.34: *Crude Oil Production in India*

State/Region	*Production (thousand tonnes)*	*Percentage to the Total Production*
1. Mumbai High	22.10	65.00
2. Gujarat	06.00	17.65
3. Assam	05.10	15.00
4. Andhra Pradesh	00.39	1.15
5. Tamil Nadu	00.37	1.10
6. Arunachal Pradesh	00.04	0.10
Total (All India)	**34.00**	**100.00**

Source: Statistical Abstracts of India 2007.

Natural Gas

Natural gas is obtained from the oil-wells. Being lighter, it overlies the oil pool and is required to be taken out first at the time of drilling oil-well. Natural gas is mainly utilised in the manufacturing of chemical fertilizers, thermal power plants, heating of industries and fuel (cooking gas).

The exploration of natural gas is being done by the Oil and Natural Gas Commission.

According to one estimate, India has a total natural gas reserve of about 450 billion cubic meters. Out of the total reserves, about 75 per cent lies in the Bassein and Bombay High, about 12 percent in Gujarat, 7 per cent in Andhra Pradesh and 6 percent in Assam. Natural gas is also found in the Barmer and Jaisalmer Districts of Rajasthan, Kangra Districts of Himachal Pradesh, and Firozepur District of Punjab. The trend of natural gas production has been shown in **Table 10.35**.

Table 10.35: *India—Trend in Natural Gas Production (2009)*

Year	*Production (million cubic meters)*
1960-61	17
1970-71	76
1980-81	200
1990-91	12,870
2000-01	20,920
2005-06	25,750

Source: Statistical Abstracts, India, *2006-07.*

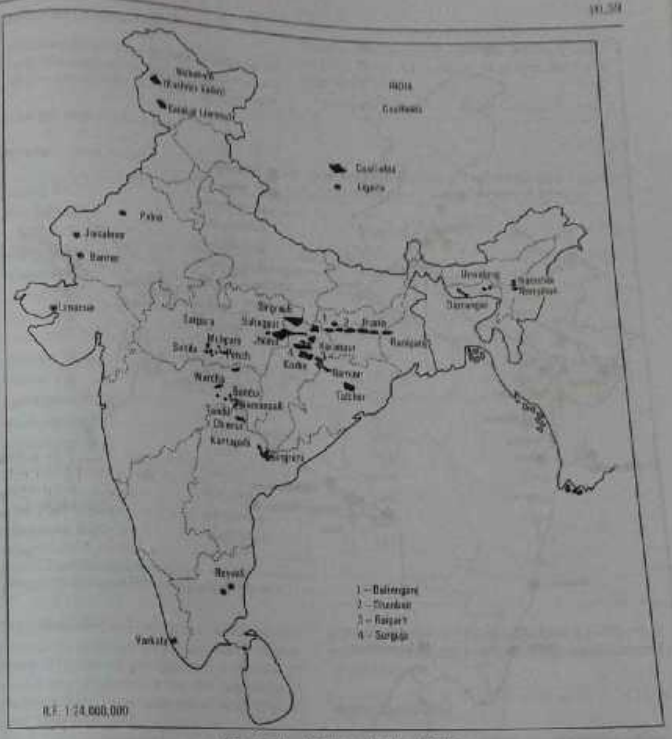

Fig. 10.20 – Major coalfields of India

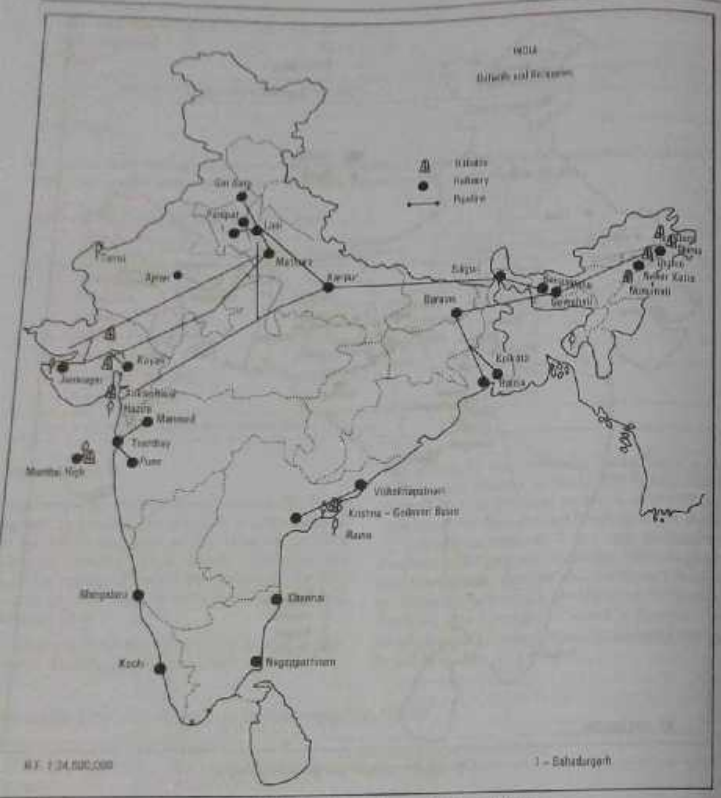

Fig. 10.21 – Oilfields and petroleum refineries of India

Oil Refineries of India

The oil refineries are the processing factories of crude oil. The impurities from the crude oil are removed to obtain petroleum, diesel, kerosene, bitumen, and aviation fuel. The main refineries of India are given in **Table 10.36** and shown in **Fig. 10.21**.

***Table 10.36:** Refineries of India*

Refinery	*State*	*Commissioned in year*	*Capacity (lakh tonnes per year)*
Digboi, IOC	Assam	1901	5.0
Trombay, HPCL	Maharashtra	1954	55.0
Trombay, BPCL	Maharashtra	1955	60.0
Vishakhapatnam, HPCAL	Andhra Pradesh	1957	45.0
Nunamati, IOC	Assam	1962	8.5
Barauni, IOC	Bihar	1964	33.5
Koyali, IOC	Gujarat	1965	95.0
Kochi, CRL	Kerala	1966	45.0
Chennai, MRL	Tamil Nadu	1969	56.0
Haldia, IOC	West Bengal	1975	27.5
Bongaigaon, BRPL	Assam	1979	13.5
Mathura, IOC	Uttar Pradesh	1982	75.0
Numaligarh, IOC	Assam	1999	30.0
Jamnagar, RP	Gujarat	1999	270.0
Kamal, IOC	Haryana	1998	60.0
Mangalore, HPCL	Karnataka	1998	30.0
Panagundi, IOC	Tamil Nadu	1999	5.0
Total			**913.5**

Source: Statistical Abstract of India, 2006-07

India is, however, not self-reliant in the matter of petroleum and petroleum products. Heavy quantity of crude-oil, petroleum and petroleum products are imported from the countries of South-West Asia, especially from Saudi Arabia, Kuwait, Iran and UAE.

The generation of electricity was started in India in 1898 when the Darjeeling Hydel Power Project was commissioned.

The first thermal power plant was installed in Kolkata in 1899. Subsequently, the Mettur Project in Tamil Nadu and Sivasamudram Project in Karnataka were commissioned. The National Thermal Power Corporation (NTPC) was established in 1975. A number of thermal power stations were established in different parts of the country to meet the growing demand of electricity.

Hydro Electricity

India is one of the leading producers of hydro-electricity in the world. At present, there are 115 hydel power projects in operation in the country. Most of the hydel projects are located in the hilly and mountainous areas of the country. The major hydro-electric power projects have been shown in **Fig. 10.22**, while their statewise distribution is given in **Table 10.37**.

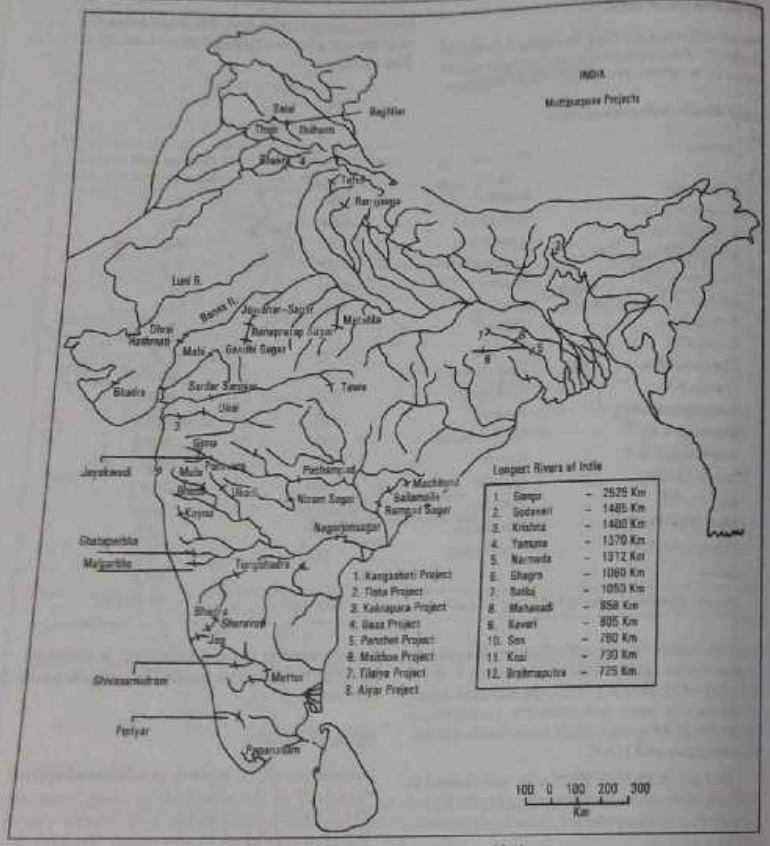

Fig. 10.22 – Multipurpose projects of India

Multipurpose Projects

Some of the important multipurpose projects of India are as under:

1. D.V.C. (Damodar Valley Corporation)
2. Mayurakshi Project in Jharkhand and West Bengal
3. Kangsabati Project in Bankura district of West Bengal
4. Tista Valley Project in West Bengal
5. Nagarjun Sagar Project in Andhra Pradesh
6. Tungbhadra Project in Andhra Pradesh and Karnataka
7. Pochampad Project in Andhra Pradesh
8. Kakrapara Project in Gujarat
9. Ukai Project in Gujarat
10. Mahi Project in Gujarat
11. Bhadra Project in Gujarat
12. Upper Krishna Project in Karnataka
13. Ghataprabha Valley Development Project in Karnataka
14. Malaprabha Project in Karnataka
15. Tawa Project in Hoshingabad district (Madhya Pradesh)
16. C.V.D. Project on the Chambal River
17. Bhima Project on Pavna River in Pune and Sholapur districts of Maharashtra
18. Hirakud Project in Odisha
19. Tawakwadi Project in Maharashtra
20. Bhakra Nangal Project in Himachal Pradesh/ Punjab
21. Beas Project in Himachal Pradesh
22. Parambikulam Alliyar Project in Tamil Nadu
23. Indira Gandhi Canal in Punjab and Rajasthan
24. Gandak Project on the Gandak River, Bihar
25. Rihand Project in Uttar Pradesh
26. Kosi Project in Bihar
27. Sabarmati Project in Gujarat
28. Panam Project in Panchmahal District of Gujarat
29. Kanjan Project in Gujarat
30. Mahanadi Reservoir in Madhya Pradesh
31. Hasdeo Bango and Bargi Projects in Madhya Pradesh
32. Sarda-Sahayak and Ramganga Project in Uttarakhand
33. Ukadi, Krishna and Upper Penganga Project in Maharashtra
34. Thein Project in Punjab

Table 10.37: Statewise Main Hydro-Electric Power Projects

	State	Names of Hydro-electric Power Plants
1.	Andhra Pradesh	Machkund, Nagarjun Sagar, Nizam Sagar, Sileru, Srisailem
2.	Bihar	Kosi
3.	Gujarat	Bhadra (Kathiawad), Hathmati (Sabarmati), Ukai (Tapi)
4.	Jammu & Kashmir	Dool Hasti, Baghliar, Salal (Chenab), Lower Jhelum
5.	Jharkhand	Maithon, Panchat, Tilaiya (all under Damodar Valley Corporation)
6.	Karnataka	Bhadra, Krishnarajsagar, Mahatma-Gandhi (Jog Falls), Munirabad, Sanavati, Sivasamudram (Kaveri)
7.	Kerala	Iddukki (Periyar), Kallada, Kuttiadidy, Pallivasal, Parmbikulam, Periyar, Poringal, Ponniar, Sabarigiri
8.	Madhya Pradesh	Jawaharsagar and Pratapsagar Pallivasal, (Chambal), Tawa (Narmada)
9.	Maharshtra	Bhola, Bhatnagar (Beed), Girnar, Khopali, Koyna, Purna, Paithon, Vaitarna
10.	North-Eastern States	Dikhu, Doyan (Nagaland), Gomuti (Tripura), Kopali (Assam), Khandong and Kyrdemkulai (Meghalaya), Loktak (Manipur), Ranganadi (Arunachal Pradesh), Sirlui and

	Barabi (Mizoram)
11. Odisha	Hirakud (Maharadi), Balimela, Bengal (Brahmani), Indravati
12. Punjab and Himachal Pradesh	Bhakra-Nangal (Sutlej), Dehar (Beas), Giri-Bata, Binwa, Chamera, Pong, Siul, Bassi, Bhabhanagar
13. Rajasthan	Rana Pratap Sagar (Chambal)
14. Tamil Nadu	Mettur, Periyar, Aliayar, Kodayar, Moyar, Papnesam, Suruliyar
15. Uttarakhand	Tehri-Dam, Koteshwar-Dam (Bhagirathi)
16. Uttar Pradesh	Rihand, Ramganga, Chibro (Tons)
17. West Bengal	Panchet

Thermal Electricity

Coal and lignite based thermal power stations contribute about 60 per cent of the total electricity generated in India. Some of the important thermal power stations of India are Patratu, Barauni and Muzaffarpur in Bihar, Talcher (Odisha), Titagarh, Mulajore, Cossipore, Durgapur, Bandel, Santaldih, Gauripur, Disergarh, Kolaghat, Farakka in West Bengal; Ahmadebad, Dhuravan, Gandhinagar, Kawas, Gandgar, Sabarmati, Ukai and Uttaran, Gujarat; Satpura, Korba (M.P.); Ballarshah, Bhusawal, Chola, Korah, Khaparkheda, Nasik, Paras, and Parli in Maharashtra **(Fig. 10.23)**.

In northern India thermal power plants are located Rajghat in Delhi, Faridabad, Panipat and Surajpur in Haryana, Chenani and Kalakot in Jammu and Kashmir, Bhatinda, in Punjab, Obra, Harduagang, Renusagar, Panki (Kanpur), Dadri, Rihand, and Singrauli in Uttar Pradesh. In southern India thermal power plants are located at Kothagudam, Vijaiwada, Ramagundam, Nellore, Ennore, Tuticorin, and Basin- Bridge (Tamil Nadu); Raichur (Karnataka) and Kochi (Kerala). Moreover, gas turbine projects are located at Kamrup, Chandrapur, Bongaigaon, and Lakwa. Waste heat recovery plants are located at Namrup, and Lower Burpani.

***Table 10.38**: Thermal Power Plants*

States	*Thermal Power Station*
1. Andhra Pradesh	Bhadrachalam, Kothagudem, Manuguru, Nellore, Ramagundam, Vijaiwada
2. Assam	Bongaigaon, Chandrapur, Namrup
3. Bihar	Barauni, Kahalgaon
4. Chhattisgarh	Korba
5. Delhi	Badarpur, Indraprastha, Rajghat
6. Gujarat	Ahmadabad, Banas, Dhuvaram, Gandhisagar, Kachchh, Kandla, Mahuva, Porbandar, Sabarmati, Shahpur, Sikka, Ukai, Utaran, Wanskhobri
7. Haryana	Faridabad, Panipat, Yamunanagar
8. Jammu & Kashmir	Kalakot
9. Jharkhand	Bokaro, Chandrapur, Subernrekha
10. Madhya Pradesh	Amarkantak, Satpura, Vindhyachal
11. Maharashtra	Ballarshah, Bhusaval, Chandrapur, Chola, Dabhol, Khapar-Kheda, Koradi, Nasik, Paras, Parli, Trombay, Uran
12. Punjab	Bhatinda, Rupnagar
13. Rajasthan	Anta, Banswara, Kota, Palana, Sawai-Madhopur

14. Odisha	Balimela, Talcher
15. Tamil Nadu	Ennore, Mettur, Neyveli, Tuticorin
16. Uttar Pradesh	Babtaich, Dadri, Ghaziabad, Gorakhpur, Harduaganj, Jawaharpur, Kanpur, Mau, Moradabad, Obra, Panki, Paricha, Singrauli, Tanda
17. West Bengal	Bakreswar, Bandel, Durgapur, Farakka, Gauripur, Kalaghat, Kolkata, Mankhandal, Santaldih, Titagarh

Bhakra-Nangal Project on the Sutlej in Himachal/Punjab; Dehar (Beas) in Mandi District, Bhabhanagar in Kinnaur District, Nathpa-Jhakri, Bassi, Baira-Siul and Chamera (H.P.); Lower Jhelum, Dool-Hasti, Baghliar, and Salal on Chenab River in Jammu and Kashmir. Ranapratap Sagar and Jawahar Sagar on Chambal, Tehri-Dam and Koteshwar Dam on Bhagirathi (Uttarakhand). Khodri, Chibro on Tons are important plants in northern India.

Plants of southern India are Lower Sileru, Upper Sileru, Machkunda in Andhra Pradesh and Odisha; Nizam-Sagar, Nagarjunsagar and Srisalam (Krishna), Tungbhadra Dam of Andhra Pradesh, Saravati, Kalinadi, Mahatma Gandhi (Jog-Falls), Bhadra, Shivasamudram (Kaveri), Shimaspura, Munirabad and Lingnamakki of Karnataka; Iddikki (Periyar), Sabarigiri, Kuttiady, Sholayar, Sengulam, Neriammangham, Parambi-Kulam Aliyar, Kallada, Pallivasal, Poringal and Ponniar of Kerala; Pykara, Mettur, Kodayar, Sholayar, Aliyar, Moyar, Sakarpathy, Suruliyar and Papanasam of Tamil Nadu.

Plants of north-east India include Dikhu, Doyang, (Nagaland), Gomuti (Tripura), Loktak (Manipur), Khandong and Kyrdemkulai (Meghalaya), Kopili (Assam), Serlui and Barabi (Mizoram), Ranganadi (Arunachal Pradesh). Damodar Valley Corporation, the first multipurpose river valley project is having an installed capacity of 2146 mw, comprising of 1920 mw thermal, 144 mw hydel and 82 mw electricity generated by gas turbines.

Nuclear Power

India has rich deposits of uranium and thorium, the fuel used in the generation of nuclear power. The atomic energy institution at Trombay (Bhabha Atomic Research Centre) was established in 1954 and the Nuclear Power Corporation of India was established in 1987 to implement the nuclear power generation programme for commercial lines.

The first nuclear power plant with a capacity of 320 mw was set up at Tarapur (Maharashtra). Subsequently, the Rawatbhata Atomic Plant (300 mw) near Kota was set up in 1969 which was followed by the establishment of Narora-U.P. (1989), Kaiga (Karnataka), and Kakrapara in Gujarat in 1993 **(Fig. 10.24)**.

The new sites for nuclear power plants are Bergi or Chutka (M.P.), Haripur (W.Bengal), Kawada (Andhra Pradesh), Kudankulam (TamilNadu), Kumharia (Haryana) and Mithi-Verdi-Kathiawad (Gujarat) **(Fig. 10.24)**

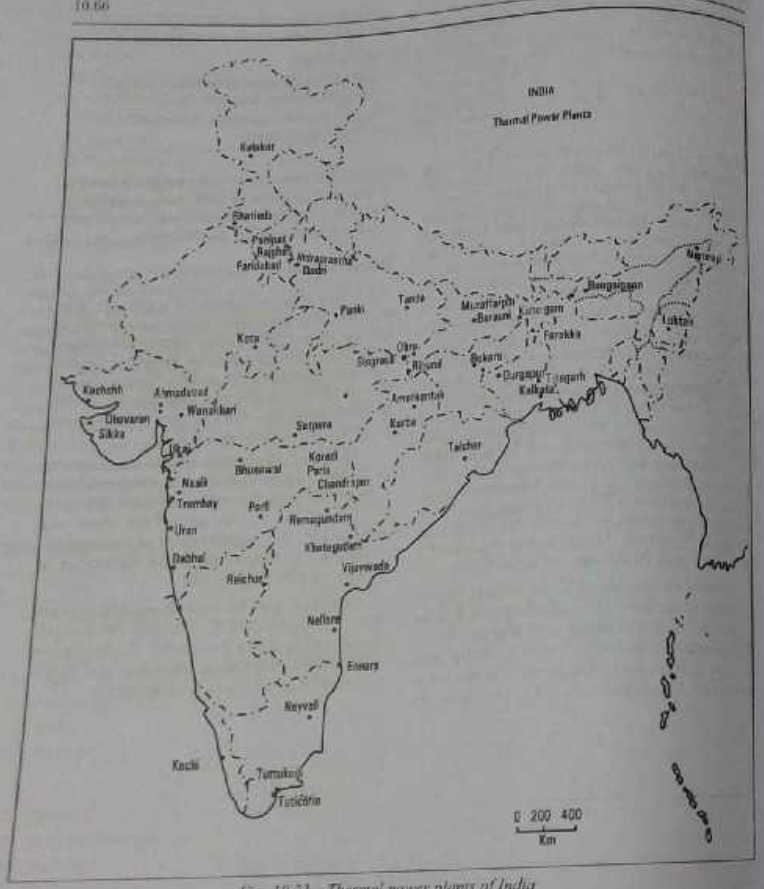

Fig. 10.23 – Thermal power plants of India

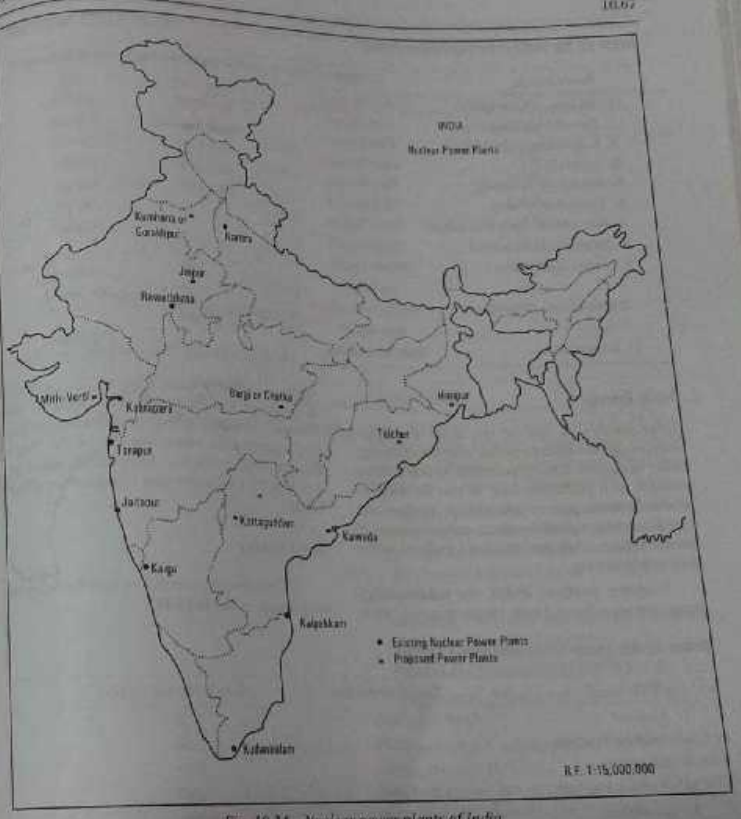

Fig. 10.24 – Nuclear power plants of India

Table 10.39: *India–Nuclear Power Plants*

Power Station	Unit	Year of Commissioning	Capacity (mw)
1. Tarapur (Maharashtra)	First Second	1969 1970	160
2. Rawatbhata (Rajasthan)	First Second	1972 1981	200 200
3. Kalpakkam (Tamil Nadu)	First Second	1984 1986	235 235
4. Narora(U.P.)	First Second	1989 1991	235 235
5. Kakrapara (Gujarat)	First Second	1993 1995	235 235
6. Kaiga (Karnataka)	First Second	1993 1995	235 235
7. Rawatbhata, Kota (Rajasthan)	Third Fourth		235 235
8. Tarapur (Maharashtra)	Third Fourth		500 500
9. Kaiga (Karnataka)	Third, Fourth and Fifth		235 (each)
10. Kawathbata (Rajasthan)	Sixth, Seventh and Eighth		500 (each)
11. Kundakulam	First and Second		1000 (each)

Solar Energy

Solar energy is one of the most important sources of non-conventional sources of energy. Solar energy is non-exhaustible, space-heating, reliable and pollution free. It can be used for water heaters, power generation devices, air-conditioning, space heating, development of pisci-culture, and multifarious uses of water and refrigeration.

In many parts of India, the solar energy programmes have been implemented. One such example is Rural Energy Co-operative at Sagar Island in Sundarban Delta of West Bengal. Similar programmes have been implemented in other islands of the Bay of Bengal, the district of Jodhpur (Rajasthan), Kalyanpur (Aligarh) and Coimbatore (Tamil Nadu).

Wind Energy

The statewise potential of wind energy has been given in **Table 10.40.**

Table 10.40: *India–Statewise Wind Energy*

State	Total Potential (mw)	Technical Potential (mw)
1. Gujarat	9675	1730
2. Andhra Pradesh	8275	1550
3. Karnataka	6620	1025
4. Madhya Pradesh	5500	1200
5. Rajasthan	5400	0885
6. Tamil Nadu	3050	1700
7. Others	6675	4725
Total	**45195**	**12835**

It may be seen from **Table 10.36** *that Gujarat has the highest wind energy potential followed by* Andhra Pradesh, Karnataka, Madhya Pradesh, Rajasthan and Tamil Nadu.

Mineral Resources

Table 10.41: *Leading Iron Ore Producing States of India*

State	Production (Thousand tonnes)	Percentage of the Total Production in the Country
1. Karnataka	25,565	25.00
2. Odisha	22,760	22.90
3. Chhattisgarh	20,435	21.98
4. Goa	18,400	19.92
5. Jharkhand	14,685	17.92
6. Others	975	14.32
Total	**102,640**	0.96
		100.00

Source: Statistical Abstracts of India, 2006–2007.

Table 10.42: *Iron Ore Deposits of India*

State	Quality	Mining Centres
1. Karnataka	Magnetite (high grade)	*Kemmangundi* (Baba-Budan Hills-Chikmagalur District), *Sandur* and Hospet (Bellary District), Chitradurga, Dharwar, Shimoga, Tumkur, Uttar Kannad.
2. Odisha	Haematite	Cuttack, Kendujhar, Koraput, *Barabil-Koira* Valley, *Badampahar* (Mayurbhanj), Sambalpur, *Kandadhar* (Sundargarh), Daitri Hill along the boundary of Kendujhar and Cuttack.
3. Chhattisgarh	Haematite	Bailadila, Dalli-Rajhara (Durg), Bilaspur, Jagdalpur, Raigarh, Surguja.
4. Goa		Pirna-Adolpale-Asnora (North Goa).
5. Jharkhand		Singhbhum, Noamandi, Santhal Pargana, Hazaribagh.
6. Others	Sederite, Limonite	Anantapur, Cuddapah, Guntur, Khammam, Kurnool, Nellore (Andhra Pradesh), Bhavnagar, Junagarh, Vadodra (Gujarat); Kangra, Mandi (Himachal Pradesh) Chandrapur, Ratnagiri, Sindhudurg (Maharashtra); Alwar, Bhilwara, Bundi, Jaipur, Udaipur (Rajasthan), Almora, Garhwal, Nainital (Uttarakhand), Mirzapur (Uttar Pradesh) Birbhum, Burdwan, Darjeeling (West Bengal).

Table 10.43: *Manganese – Leading Producing States of India* **(Fig. 10.26)**

State	Production (thousand tonnes)	Percentage of the Total Production of the Country	Major Mining Districts/Centres
1. Odisha	715	38.55	Bolangir, Kalahandi, Koraput, Sambalpur, Sundargarh
2. Maharashtra	425	22.91	Bhandara, Nagpur, Ratnagiri
3. Madhya Pradesh	365	19.68	Balaghat and Chhindwara
4. Karnataka	245	13.20	Bellary, Chitradurga, Shimoga, Tumkur, Uttara Kannad
5. Andhra Pradesh	85	4.58	Cuddapah, Guntur, Srikakulam, Vizianagram, Vishakhapatnam
6. Others	20	1.08	Goa, Panchmahal and Vadodra (Gujarat), Dhanbad, Singhbhum (Jharkhand), Udaipur (Rajasthan)
Total (All India)	**1855**	**100.00**	

Source: Statistical Abstracts of India 2007 – 2008.

Table 10.44: *Copper–Leading Producing States of India* **(Fig. 10.26)**

State	Production (thousand tonnes)	Percentage of the Total Production of India	Major Mining Districts/Centres
1. Madhya Pradesh	89	55.97	Malanjkhand (Balaghat), Badgaon (Betul)
2. Rajasthan	65	40.80	Ajmer, Bhilwada, Chittorgarh Dungarpur, Jaipur, Khetri (Jhunjhunu), Pali, Sikar, Singhana Sirohi
3. Jharkhand	05	03.14	Hazaribagh, Santhal Pargana
Total (All India)	159	100.00	

Source: Statistical Abstracts 2007 – 2008.

Table 10.45: *Bauxite–Leading Producing States of India* **(Fig. 10.27)**

State	Production (thousand tonnes)	Percentage of the Total Production of India	Major Mining Districts/Centres
1. Odisha	4904	50.16	Bolangir, Kalahandi, Koraput, Sundergarh, Sambalpur
2. Gujarat	1547	15.82	Amreli, Bhavnagar, Jamnagar, Junagarh, Kachchh
3. Jharkhand	1161	11.87	Dumka, Lohardaga, Palamu, Ranchi
4. Maharashtra	964	9.87	Kolhapur, Pune, Ratnagiri, Satara, Thane

5. Chhattisgarh	604	5.18	Ratnawantak-Pathar, Bilaspur, Durg, Raigarh, and Surguja
6. Tamil Nadu	268	2.74	Madurai, Nilgiri, and Salem
7. Madhya Pradesh	230	2.35	Balaghat, Katni, Jabalpur, Maikal range, Mandla, Shahdol
8. Others	99	1.01	Andhra Pradesh, Goa, Jammu & Kashmir, and Kerala
Total (All India)	**9772**	**100.00**	

Source: Statistical Abstracts, 2007 – 08.

Table 10.46: *Mica – Leading Producing States of India*

State	Production (thousand tonnes)	Percentage of the Total Production of India	Major Mining Districts/Centres
1. Andhra Pradesh	910	71.15	Khammam, Krishna, Nellore, Vishakhapatnam, and West Godavari
2. Rajasthan	205	16.03	Ajmer, Bhilwara, Dungarpur, Sikar, Tonk, Udaipur
3. Jharkhand	148	11.57	Dhanbad, Giridih, Hazaribagh, Koderma, Ranchi, Singhbhum
4. Bihar	16	01.25	Bhagalpur, Gaya, Munger
Total (All India)	**1279**	**100.00**	

Source: Statistical Abstracts of India 2007-08.

Table 10.47: *Limestone – Leading Producing States of India*

State	Production (thousand tonnes)	Percentage of the Total Production of India	Major Mining Districts/Centres
1. Rajasthan	240	16.15	Ajmer, Alwar, Bikaner, Chittaurgarh, Durgapur, Kota, Nagaur, Pali
2. Madhya Pradesh	238	16.01	Betul, Damoh, Jabalpur, Rewa, Satna, Sagar
3. Andhra Pradesh	235	15.81	Cuddapah, Guntur, Kurnool, Krishna, Nalgonda, Warangal
4. Gujarat	160	10.77	Amreli, Junagarh, Kheda, Surat
5. Chhattisgarh	140	09.42	Bastar, Bilaspur, Durg, Raigarh, Raipur
6. Tamil Nadu	138	09.29	Coimbatore, Madurai, Salem, Thanjavur
7. Karnataka	125	08.41	Bijapur, Gulbarga, Shimoga
8. Maharashtra	090	06.06	Chandrapur, Naded, Ahmadnagar, Yavatmal
9. Himachal Pradesh	068	04.58	Bilaspur, Chamba, Kangra
10. Odisha	025	01.68	Kalahandi, Sambalpur, Sundergarh

11. Others	027	01.82	Debari Dun, Mussoorie, Darjeeling, Jammu, Mahendergarh, Mirzapur
Total (All India)	**1486**	**100.00**	

***Table 10.48:** Dolomite – Leading Producing States of India*

State	*Production (Thousand Tonnes)*	*Percentage of the Total Production of India*	*Major Mining Districts/Centres*
1. Odisha	1075	28.71	Cangapur, Koraput, Sambalpur, Sudargarh
2. Chhattisgarh	1025	27.38	Bastar, Bilaspur, Durg, Raigarh
3. Andhra Pradesh	687	18.35	Anantapur, Kurnool, Khammam
4. Jharkhand	295	07.88	Chaibasa, Palamu, Singhbhum
5. Rajasthan	215	05.74	Ajmer, Alwar, Bhilwara, Jaipur, Jaisalmer, Jhunjhunu, Jodhpur, Nagaur, Pali, Sawai Madhopur, Sikar, and Udaipur
6. Karnataka	212	05.66	Belgaum, Bijapur, Chitradurga, Mysore, Uttar Kannad, and Tumkur
Others	235	06.28	Arunachal Pradesh, Haryana, Himachal Pradesh, Maharashtra, Tamil Nadu, Uttarakhand, Uttar Pradesh, and West Bengal
Total (All India)	**3744**	**100.00**	

Source: Statistical Abstracts, 2007–08.

Cotton Textile Industry

Cotton textile is one of the largest industries of India in terms of output, employment and foreign exchange. Its share in the industrial production is 14 per cent. Moreover, it provides 10 per cent of the excise collection, 18 per cent of employment in the industrial sector, 20 per cent of the country's total export and 4 per cent of the GDP. India enjoyed the monopoly in the production of textile goods from 1500 B.C. to 1500 A.D. Indian cotton and silk products were in great demand all over the world. The arrival of the British in India, however, led to the downfall of Indian textile manufacturing.

The first textile mill in India was established by C.N. Dewar at Mumbai, in 1854. This industry expanded fast in the ending parts of the 19th century and in the 20th century. At present India is one of the leading producers and exporter of cotton goods. The distribution of cotton textiles have been shown in **Fig. 10.29**, while the statewise production has been given in **Table 10.49**.

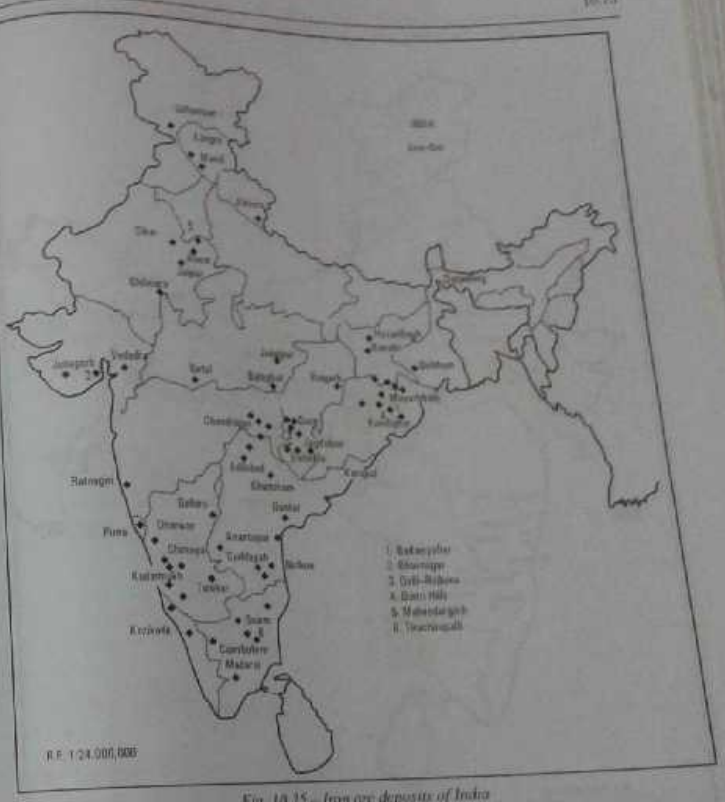

Fig. 10.25 – Iron ore deposits of India

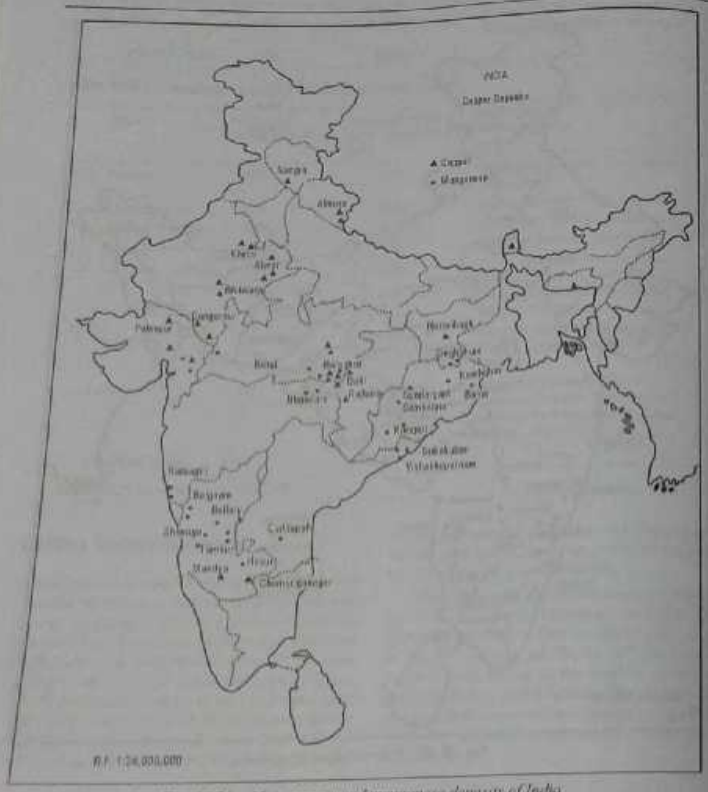

Fig. 10.26 – Main copper and manganese deposits of India

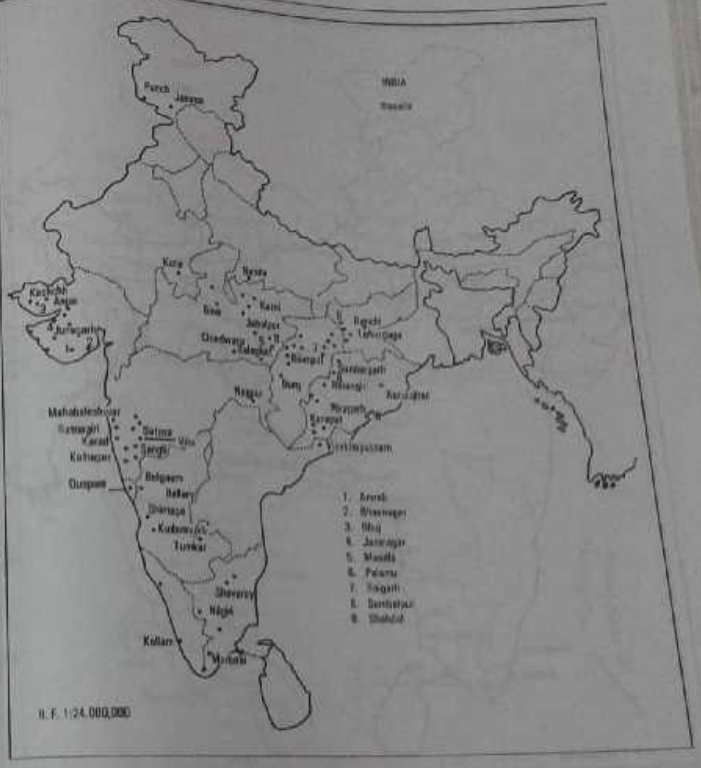

Fig. 10.27 – Bauxite deposits of India

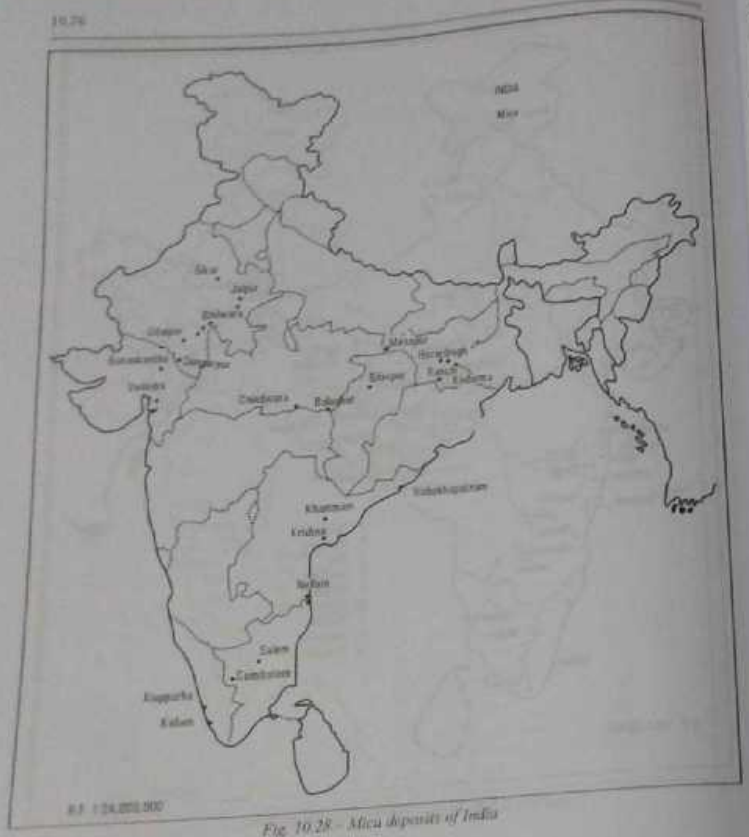

Fig. 10.28 – Mica deposits of India

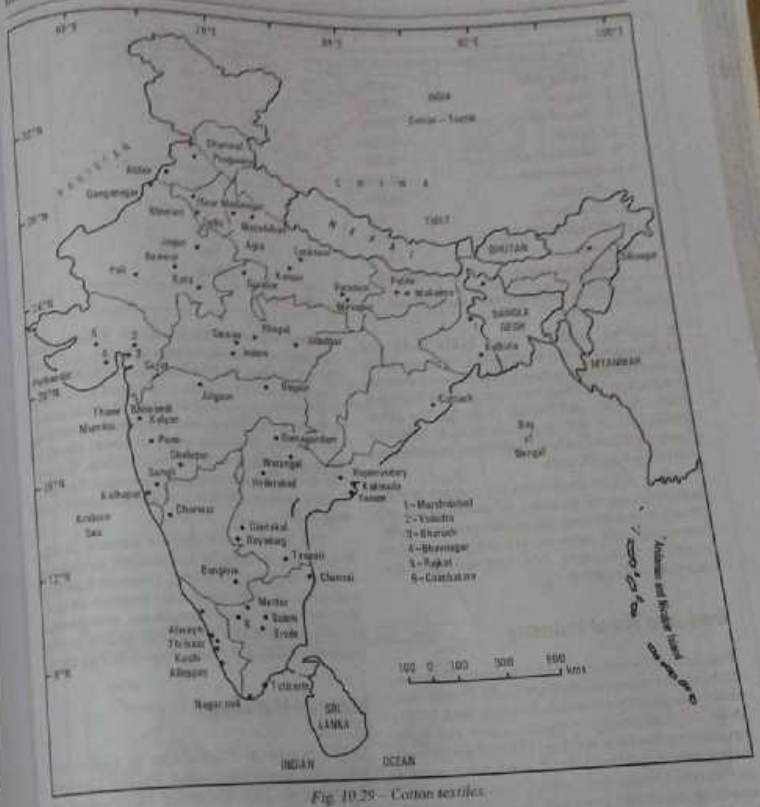

Fig. 10.29 – Cotton textiles

Table 10.49: India–Statewise Production of Cotton Cloth

State/Union Territories	Production (sq. metres)	Percentage of All India Production
1. Maharashtra	403,550	38.89
2. Gujarat	355,745	34.54
3. Tamil Nadu	65,850	6.40
4. Punjab	56,850	5.53
5. Madhya Pradesh	48,500	4.70
6. Uttar Pradesh	32,850	3.20
7. Rajasthan	26,880	2.80
8. Puducherry	25,250	2.45
9. Karnataka	8,500	0.82
10. Kerala	6,800	0.67
Total (All India)	**10,29,825**	**100.00**

Source: Data computed from the Statistical Abstracts, 2007 – 08.

It may be observed from **Table 10.49** that Maharashtra is the leading producer of cotton goods contributing about 39 per cent of the total production, followed by Gujarat (34.54 %), Tamil Nadu (6.4%), and Punjab (5.53 %). The other producers of cotton goods include Madhya Pradesh, Uttar Pradesh, Rajasthan, Puducherry, Karnataka and Kerala.

The main problems of cotton textile industries are (i) shortage of raw material, (ii) Obsolete machinery, (iii) erratic power supply, (iv) strikes and lockouts, (v) competition with synthetic fibres, and (vi) competition in the international market.

Iron and Steel Industry

Iron and steel is one of the oldest industries of India. Its history is more than 4000 years old. The famous iron pillar near Qutab Minar is dating back to 350 A.D. The first attempt to produce iron and steel on modern lines was made in 1830 at Porto Nova near Chennai (Madras). But it was not successful as charcoal was the main source of energy for the smelting of iron ore. The real progress in iron and steel industry was made in 1907 when J.N. Tata established the iron-smelting factory at Sakchi (former name of Jamshedpur). Tremendous progress in the iron and steel industry was made during the Second Five Year Plan (1956-61) when the Government of India established steel plants at Bhilai, Durgapur and Rourkela in collaboration with the Soviet, British, and German governments respectively. The other important steel plants of India are located at Bhadravati, Salem, Bokaro, Paradwip, Vishakhaputnam, Vijainagar, Burnpur, Kalinganagar, Daitre Gopalpur, and Dolvi (**Fig. 10.30**).

The Damodar Valley is known as the Khur Basin of India. It has several complexes of iron and steel, smelting, machine-building and fertilizer industries. The location of coal, iron-ore mines, copper limestone, manganese, chromite and major industrial places in the Damodar Valley have been shown in **Fig. 10.31**.

National Highways

The National Highways in India are developed and maintained by the Central Government. The National Highways of India have been shown in **Fig. 10.32**, while **Table 10.50** gives the main cities on the different National Highways.

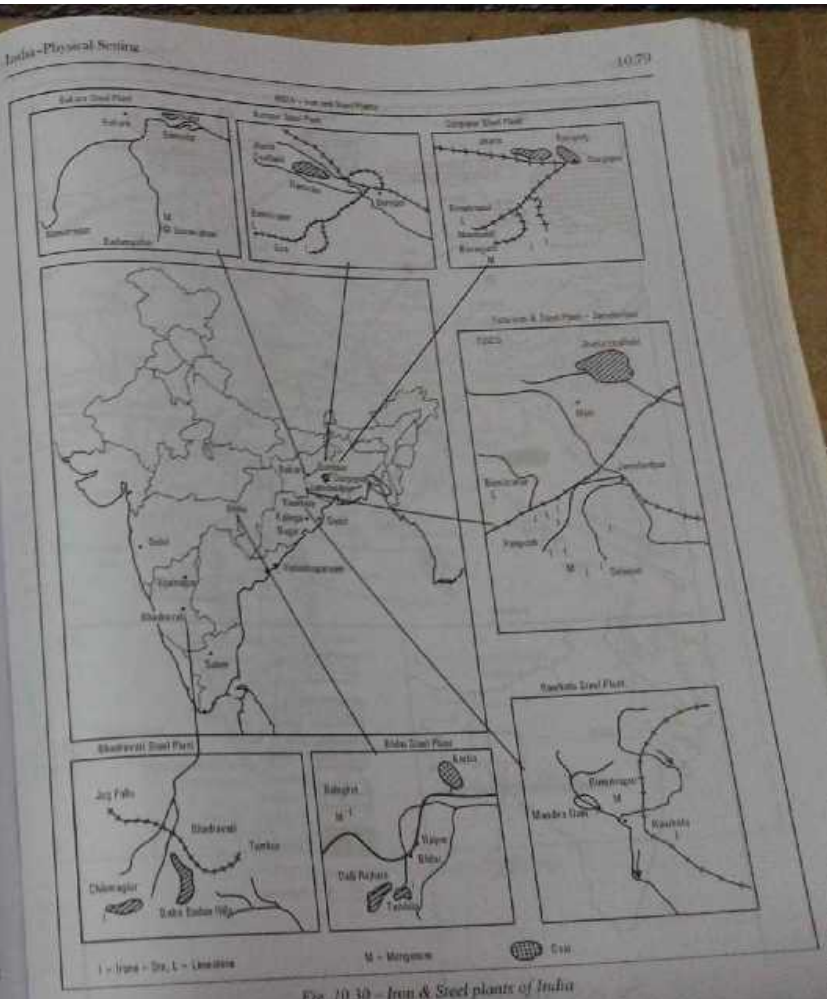

Fig. 10.30 – Iron & Steel plants of India

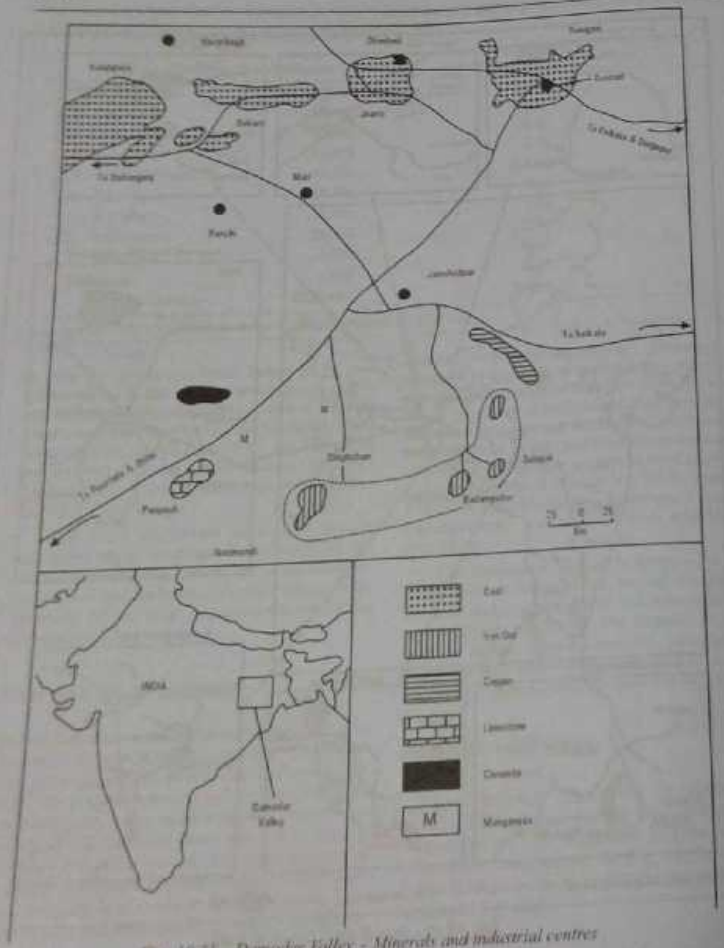

Fig. 10.31 – Damodar Valley - Minerals and industrial centres

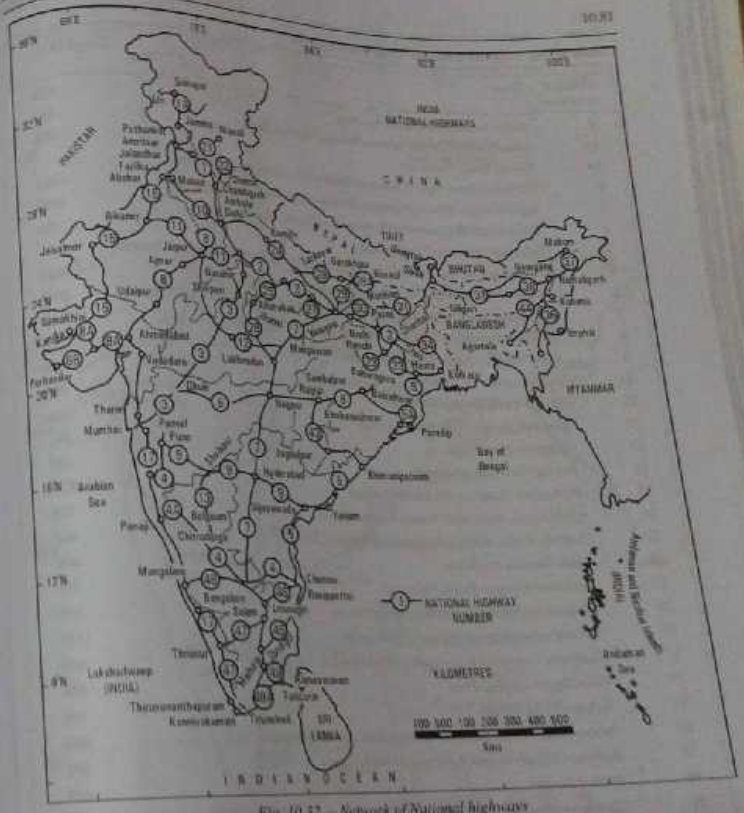

Fig. 10.32 – Network of National highways

Table 10.50: Important National Highways of India

National Highway	Route	Length in km
1	Delhi-Ambala-Jalandhar-Amritsar	456
1A	Jalandhar-Madhopur-Jammu-Srinagar-Baramulla-Uri	663
1B	Batote, Tinda, Kishtwar	274
2	Delhi-Mathura-Agra-Kanpur-Allahabad-Varanasi-Barh-Kolkata	1161
3	Agra-Gwalior-Shivpuri-Indore-Dhulia-Nasik-Thane-Mumbai	1533
4	Thane-Pune-Belgaum-Hubli-Bangalore-Ranipet-Chennai	153
4A	Belgaum-Anmode-Ponda-Panaji	
5	Baharagora-Cuttack-Bhubaneshwar-Vishakhapatnam-Vijaywada-Chennai	1645
6	Dhule-Nagpur-Raipur-Sambalpur-Baharagora-Kolkata	2369
7	Varanasi-Rewa-Jabalpur-Nagpur-Hyderabad-Bangalore-Madurai-Kanniyakumari	1428
8	Delhi-Jaipur-Ajmer-Udaipur-Ahmadabad-Vadodra-Mumbai	791
9	Pune-Solapur-Hyderabad-Vijaywada	403
10	Delhi-Fazilka	702
11	Agra-Bharatpur-Jaipur-Bikaner	890
12	Jabalpur-Bhopal-Kota-Bundi-Jaipur	491
13	Solapur-Chitradurga	450
14	Beawar-Sirohi-Radhanpur	1526
15	Pathankot-Bhatinda-Bikaner-Jaisalmer	323
21	Chandigarh-Rupnagar-Mandi-Kullu-Manali	402
22	Ambala-Kalka-Shimla-Narkanda-Rampur-Chini	438
24	Delhi-Bareilly-Lucknow	379
25	Lucknow-Kanpur-Jhansi-Shivpuri	570
28	Barauni-Muzaffarpur-Gorakhpur-Lucknow	1123
31	Bakhtiyarpur-Siliguri-Nalbari-Amisigaon	680
37	Goalpara-Guwahati-Kumargaon-Saikhoa Ghat	436
39	Numaligarh-Imphal Palel	560
43	Raipur-Vizianagram	640
47	Salem-Coimbatore-Thiruvananthapuram-Kanniyakumari	850
52	Balhata-Charali-Tezpur-Lakhimpur-Sekhoaghat	560
54	Silchar-Aizawl	285
56	Lucknow-Varanasi	

Golden Quadrilateral (GQ): The National Highways Development Project (NHDP) launched a massive programme in 1999 known as Golden Quadrilateral **(Fig. 10.33)**. The length of the different sectors has been given in **Table 10.51**.

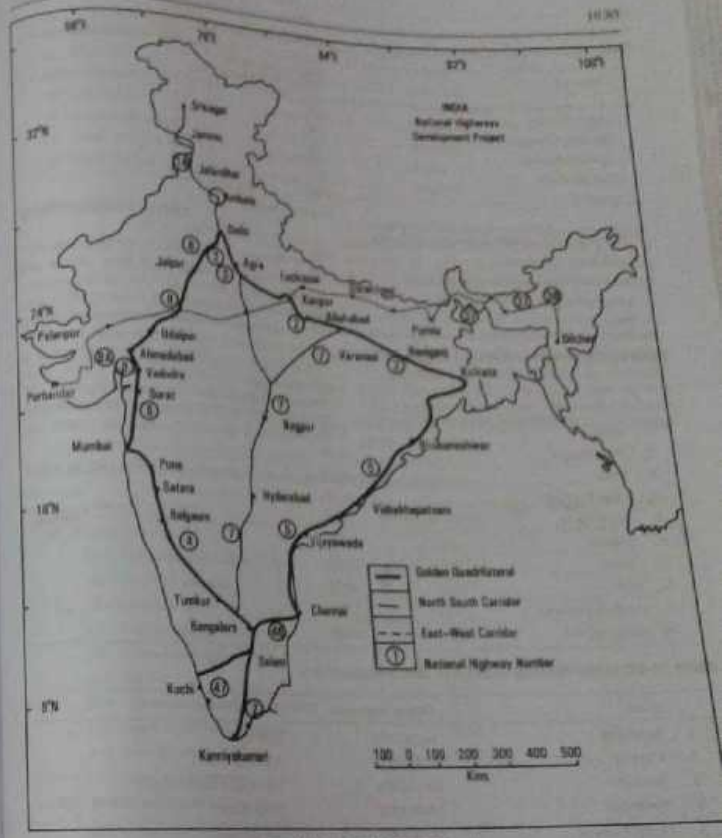

Fig. 10.33 - Golden Quadrilateral

Table 10.51: *Length of Various Sections of the Golden Quadrilateral*

Name	Length of sides of the Golden Quadrilateral in km
Delhi-Mumbai	1419
Mumbai-Chennai	1290
Chennai-Kolkata	1684
Kolkata-Delhi	1453
Total	**5846**
	Length of Corridor
North-South Corridor, connecting Srinagar with Kanniyakumari	4000
East-West Corridor connecting Silchar with Porbandar	3300
Total	**7300**

Table 10.52: *Length of Railways in some of the States*

	State	Length of Railway (in km per 1000 sq km)
1.	Punjab	42.78
2.	West Bengal	41.85
3.	Bihar	30.82
4.	Uttar Pradesh	30.20
5.	Tamil Nadu	29.96
6.	Gujarat	28.73
7.	Assam	27.58
8.	Goa	20.72
9.	Andhra Pradesh	17.39
10.	Maharashtra	17.20

Table 10.53: *Indian Railway Zones and their Headquarters*

	Zone	Date of Formation	Headquarters
1.	Southern	14.04.1951	Chennai
2.	Central	05.11.1951	Mumbai (CST)
3.	Western	05.11.1951	Mumbai (Church Gate)
4.	Northern	14.04.1952	New Delhi
5.	North-Eastern	14.04.1952	Gorakhpur
6.	South-Eastern	01.08.1955	Kolkata
7.	Eastern	01.08.1955	Kolkata
8.	North-Eastern Frontier	15.01.1958	Maligaon (Guwahati)

9.	South Central	02.10.1966	Secunderabad
10.	East Central	05.10.2002	Hajipur
11.	North-Western	01.10.2002	Jaipur
12.	East Coast	01.04.2003	Bhubaneshwar
13.	North Central	01.04.2003	Allahabad
14.	South-East Central	01.04.2003	Bilaspur
15.	South Western	01.04.2003	Hubli
16.	West Central	01.04.2003	Jabalpur

International Trade

The developed and wealthy countries of the world, with their aggressive market-led economies as well as access to productive new technologies and international markets, dominate the world economic system. At the other extreme, many of the countries of the developing world are locked in a cycle of national debt, rising population and unemployment. The state-managed economies of the former communist bloc began to be dismantled during the 1990s. At present, China and India are emerging as the major economic powers in the international trade. World trade acts as a stimulus to national economies, encouraging growth. Over the last three decades, as heavy industries have declined

services-banking, insurance, tourism, airlines, and shipping have taken an increasingly large share of world trade. Manufactured articles now account for nearly two thirds of world trade; raw materials and food make up less than a quarter of the total. The major exports and imports of India have been given in **Tables 10.54 and 10.55**.

Table 10.54 : *India – Commodity Composition of Exports (2006-07)*

	Commodity Group	Percentage Share 2006-07
I.	Primary Products	15.40
	(i) Agriculture and allied	10.20
	(ii) Ores and minerals	05.20
II.	Manufactured Goods	65.70
	(i) Engineering goods	20.70
	(ii) Gems and jewellery	15.10
	(iii) Textiles	14.50
	(iv) Chemicals and related products	11.80
	(v) Leather and leather goods	02.60
	(vi) Handicrafts excluding hand made carpets	01.20
III.	Petroleum-crude and products including coal	11.50
IV.	Others	07.40
	Total	**100.00**

Table 10.55: India – Imports of Principal Commodities (2006-07)

	Commodity	Percentage Share
1.	Petroleum, crude-oil and petroleum products	33.70
2.	Capital goods	12.10
3.	Electronic goods	09.40
4.	Gold and silver	08.60
5.	Chemicals	05.50
6.	Pearls, precious and semi-precious stones	04.10
7.	Metal scrap	03.90
8.	Coke coal, and briquettes	02.40
9.	Edible oils	01.30
10.	Professional instruments and optical goods	01.30
11.	Other commodities	17.70
	Total	**100.00**

Salient Features of India's International Trade: (i) Unfavourable Balance of Trade, (ii) More export of manufactured goods, (iii) world-wide trade, (iv) about 96 per cent of the trade is carried by sea route, (v) increasing import of raw material, (vi) increasing import of capital goods like metals, electrical and non-electrical machinery, transport equipments chemicals and new technology, (vii) low position in international trade.

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Mineral Resources

***Table 10.37:** Leading Iron Ore Producing States of India*

State	*Production (thousand tonnes)*	*Percentage of the Total Production in the Country*
1. Karnataka	25,565	24.90
2. Odisha	22,560	21.98
3. Chhattisgarh	20,455	19.92
4. Goa	18,400	17.92
5. Jharkhand	14,685	14.32
6. Others	975	0.96
Total	**102,640**	**100.00**

Source: Statistical Abstracts of India, 2006-2007.

***Table 10.38:** Iron-Ore Deposits of India*

State	*Quality*	*Mining Centres*
1. Karnataka	Magnetite (high grade)	*Kemmangundi* (Baba-Budan Hills-Chikmagalur District), *Sandur* and *Hosepet* (Bellary District), Chitradurga, Dharwar, Shimoga, Tumkur, Uttar Kannad.
2. Odisha	Haematite	Cuttack, Kendujhar, Koraput, *Barabil-Koira* Valley, *Badampahar* (Mayurbhanj), Sambalpur, *Kandadhar* (Sundargarh), Daitri Hill along the boundary of Kendujhar and Cuttack.
3. Chhattisgarh	Haematite	Bailadila, Dalli-Rajhara (Durg), Bilaspur, Jagdalpur, Raigarh, Surguja.
4. Goa		Pirna-Adolpale-Asnora (North Goa).
5. Jharkhand		Singhbhum, Noamandi, Santhal Pargana, Hazaribagh.
6. Others	Sederite, Limonite	Anantapur, Cuddapah, Guntur, Khammam, Kurnool, Nellore (Andhra Pradesh), Bhavnagar, Junagarh, Vadodra (Gujarat): Kangra, Mandi (Himachal Pradesh) Chandrapur, Ratnagiri, Sindhudurg (Maharashtra): Alwar, Bhilwara, Bundi, Jaipur, Udaipur (Rajasthan), Almora, Garhwal, Nainital (Uttarakhand), Mirzapur (Uttar Pradesh) Birbhum, Burdwan, Darjeeling (West Bengal).

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Table 10.39: Manganese – Leading Producing States of India (Fig. 10.26)

State	Production (thousand tonnes)	Percentage of the Total Production of the Country	Major Mining Districts/Centres
1. Odisha	715	38.55	Bolangir, Kalahandi, Koraput, Sambalpur, Sundargarh
2. Maharashtra	425	22.91	Bhandara, Nagpur, Ratnagiri
3. Madhya Pradesh	365	19.68	Balaghat and Chhindwara
4. Karnataka	245	13.20	Bellary, Chitradurga, Shimoga, Tumkur, Uttari-Kannad
5. Andhra Pradesh	85	4.58	Cuddapah, Guntur, Srikakulam, Vijainagram, Vishakhapatnam
6. Others	20	1.08	Goa, Panchmahal and Vadodra (Gujarat), Dhanbad, Singhbhum (Jharkhand) Udaipur (Rajasthan)
Total (All India)	**1855**	**100.00**	

Source: Statistical Abstracts of India 2007 – *2008.*

Table 10.40: Copper–Leading Producing States of India (Fig. 10.26)

State	Production (thousand tonnes)	Percentage of the Total Production of India	Major Mining Districts/Centres
1. Madhya Pradesh	89	55.97	Malanjkhand (Balaghat), Badgaon (Betul)
2. Rajasthan	65	40.80	Ajmer, Bhilwada, Chittorgarh Dungarpur, Jaipur, Khetri (Jhunjhunu), Pali, Sikar, Singhana Sirohi
3. Jharkhand	05	03.14	Hazaribagh, Santhal Pargana
Total (All India)	159	100.00	

Source: Statistical Abstracts 2007 – 2008.

Table 10.41: Bauxite–Leading Producing States of India (Fig. 10.27)

State	Production (thousand tonnes)	Percentage of the Total Production of India	Major Mining Districts/Centres
1. Odisha	4904	50.16	Bolangir, Kalahandi, Koraput, Sundergarh, Sambalpur
2. Gujarat	1547	15.82	Amreli, Bhavnagar, Jamnagar, Junagarh, Kachchh
3. Jharkhand	1161	11.87	Dumka, Lohardaga, Palamu, Ranchi

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4.	Maharashtra	964	9.87	Kolhapur, Pune, Ratnagiri, Satara, Thane
5.	Chhattisgarh	604	6.18	Amarkantak-Pathar, Bilaspur, Durg, Raigarh, and Sarguja
6.	Tamil Nadu	268	2.74	Madurai, Nilgiri, and Salem
7.	Madhya Pradesh	230	2.35	Balaghat, Katni, Jabalpur, Maikal range, Mandla, Shahdol
8.	Others	99	1.01	Andhra Pradesh, Goa, Jammu & Kashmir, and Kerala
	Total (All India)	**9777**	**100.00**	

Source: Statistical Abstracts, 2007 – 08.

***Table 10.42:** Mica – Leading Producing States of India*

	State	*Production (thousand tonnes)*	*Percentage of the Total Production of India*	*Major Mining Districts/Centres*
1.	Andhra Pradesh	910	71.15	Khammam, Krishna, Nellore, Vishakhapatnam, and West Godavari
2.	Rajasthan	205	16.03	Ajmer, Bhilwara, Dungarpur, Sikar, Tonk, Udaipur
3.	Jharkhand	148	11.57	Dhanbad, Giridih, Hazaribagh, Kodarma, Ranchi, Singhbhum
4.	Bihar	16	01.25	Bhagalpur, Gaya, Munger
	Total (All India)	**1279**	**100.00**	

Source: Statistical Abstracts of India 2007–08.

***Table 10.43:** Limestone – Leading Producing States of India*

	State	*Production (thousand tonnes)*	*Percentage of the Total Production of India*	*Major Mining Districts/Centres*
1.	Rajasthan	240	16.15	Ajmer, Alwar, Bikaner, Chittaurgarh, Dungarpur, Kota, Nagaur, Pali
2.	Madhya Pradesh	238	16.01	Betul, Damoh, Jabalpur, Rewa, Satna, Sagar
3.	Andhra Pradesh	235	15.81	Cuddapah, Guntur, Kurnool, Krishna, Nalgonda, Warangal
4.	Gujarat	160	10.77	Amreli, Junagarh, Kheda, Surat
5.	Chhattisgarh	140	09.42	Bastar, Bilaspur, Durg, Raigarh, Raipur
6.	Tamil Nadu	138	09.29	Coimbatore, Madurai, Salem, Thanjavur
7.	Karnataka	125	08.41	Bijapur, Gulbarga, Shimoga

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8.	Maharashtra	090	06.06	Chandrapur, Naded, Ahmadnagar, Yavatmal
9.	Himachal Pradesh	068	04.58	Bilaspur,Chamba,Kangra
10.	Odisha	025	01.68	Kalahandi, Sambalpur, Sundergarh
11.	Others	027	01.82	Dehra Dun, Mussoorie, Darjeeling, Jammu, Mahendergarh, Mirzapur
	Total (All India)	**1486**	**100.00**	

***Table 10.44:** Dolomite – Leading Producing States of India*

	State	*Production (thousand tonnes)*	*Percentage of the Total Production of India*	*Major Mining Districts/Centres*
1.	Odisha	1075	28.71	Gangapur, Koraput, Sambalpur, Sudargarh
2.	Chhattisgarh	1025	27.38	Bastar, Bilaspur, Durg, Raigarh
3.	Andhra Pradesh	687	18.35	Anantapur, Kurnool, Khammam
4.	Jharkhand	295	07.88	Chaibasa, Palamu, Singhbhum
5.	Rajasthan	215	05.74	Ajmer, Alwar, Bhilwara, Jaipur, Jaisalmer, Jhunjhunu, Jodhpur, Nagaur, Pali, Sawai Madhopur, Sikar, and Udaipur
6.	Karnataka	212	05.66	Belgaum, Bijapur, Chitradurga, Mysore, Uttar-Kannad, and Tumkur
	Others	235	06.28	Arunachal Pradesh, Haryana, Himachal Pradesh, Maharashtra, Tamil Nadu, Uttarakhand, Uttar Pradesh, and West Bengal
	Total (All India)	**3744**	**100.00**	

Source: Statistical Abstracts, 2007–08.

Cotton Textile Industry

Cotton textile is one of the largest industries of India in terms of output, employment and foreign exchange. Its share in the industrial production is 14 per cent. Moreover, it provides 10 per cent of the excise collection, 18 per cent of employment in the industrial sector, 20 per cent of the country's total export and 4 per cent of the GDP. India enjoyed the monopoly in the production of textile goods from 1500 B.C. to 1500 A.D. Indian cotton and silk products were in great demand all over the world. The arrival of the British in India, however, led to the downfall of Indian textile manufacturing.

The first textile mill in India was established by C.N. Dewar at Mumbai, in 1854. This industry expanded fast in the ending parts of the 19th century and in the 20th century. At present India is one of the leading producers and exporter of cotton goods. The distribution of cotton textiles have been shown in **Fig. 10.29**, while the statewise production has been given in **Table 10.45**.

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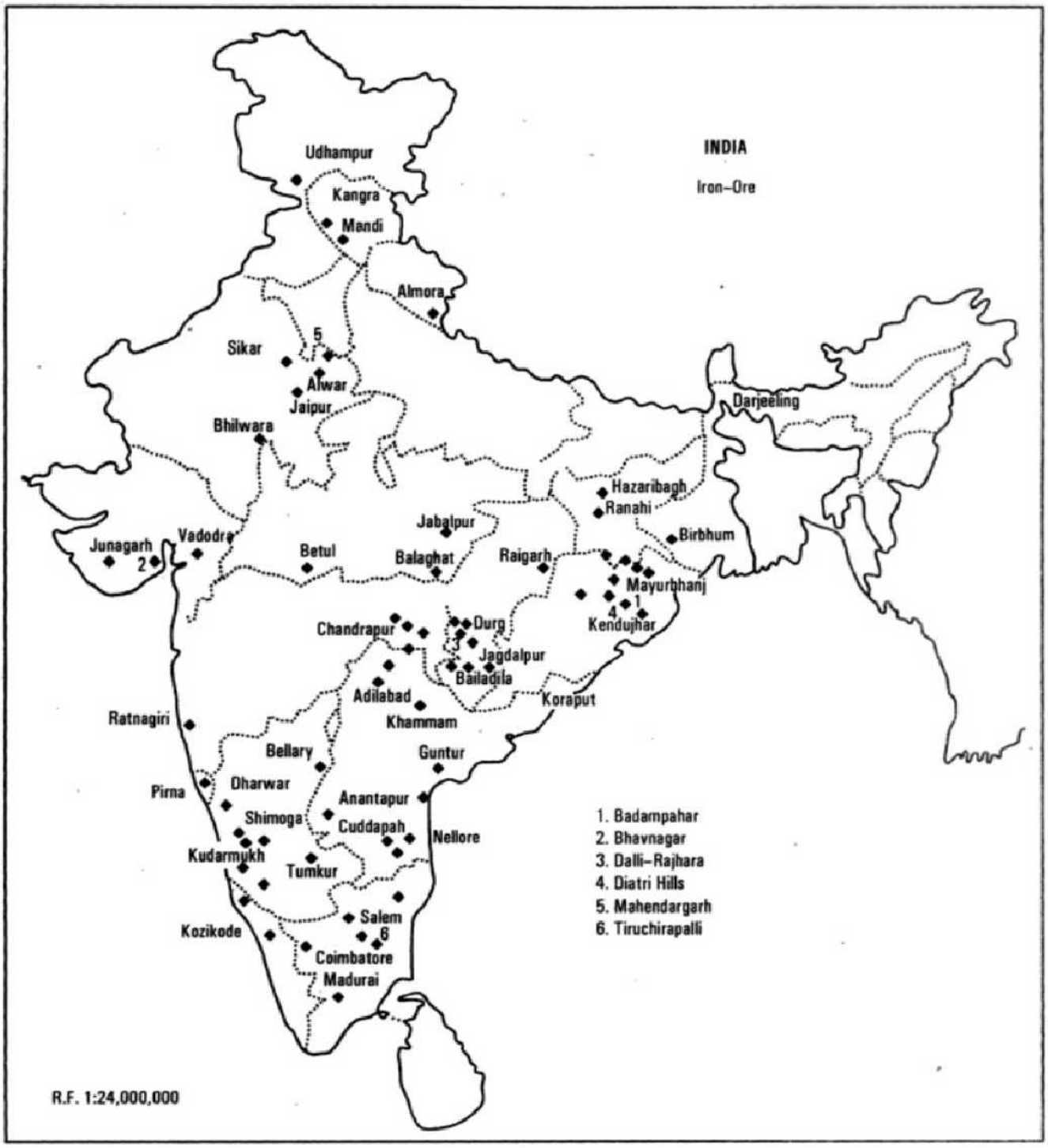

Fig. 10.25 – Iron ore deposits of India

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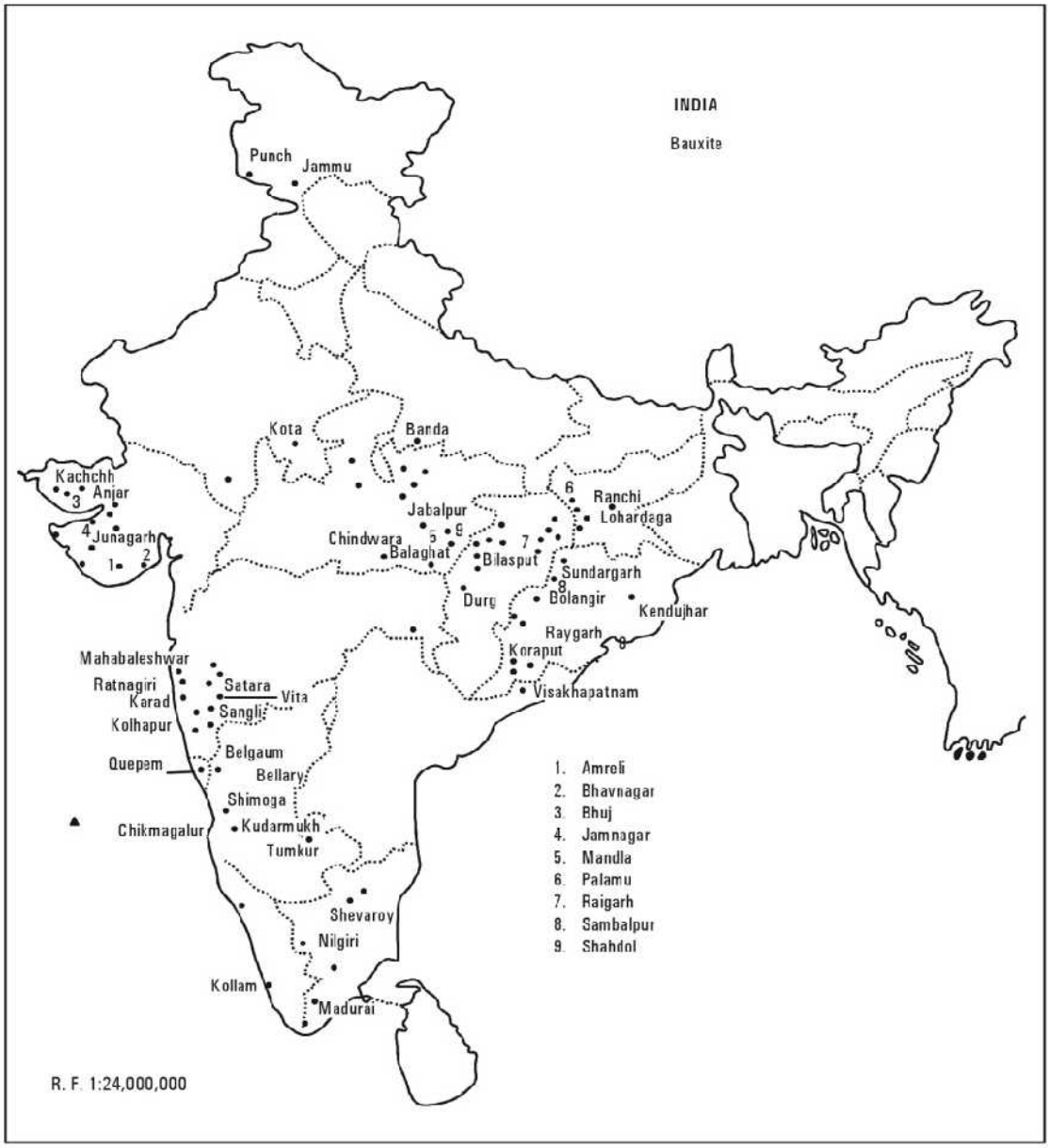

Fig. 10.27 – Bauxite deposits of India

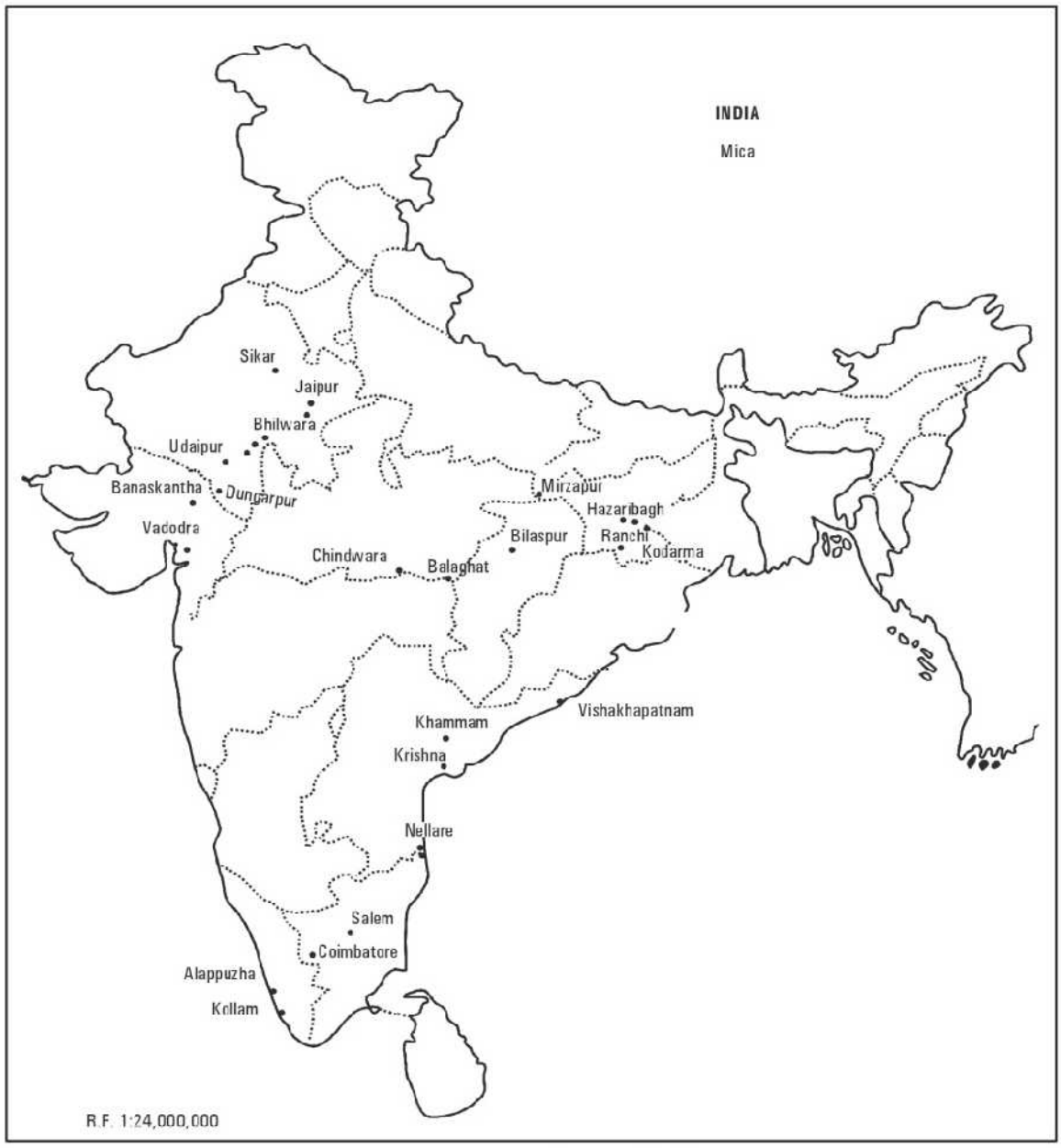

Fig. 10.28 – Mica deposits of India

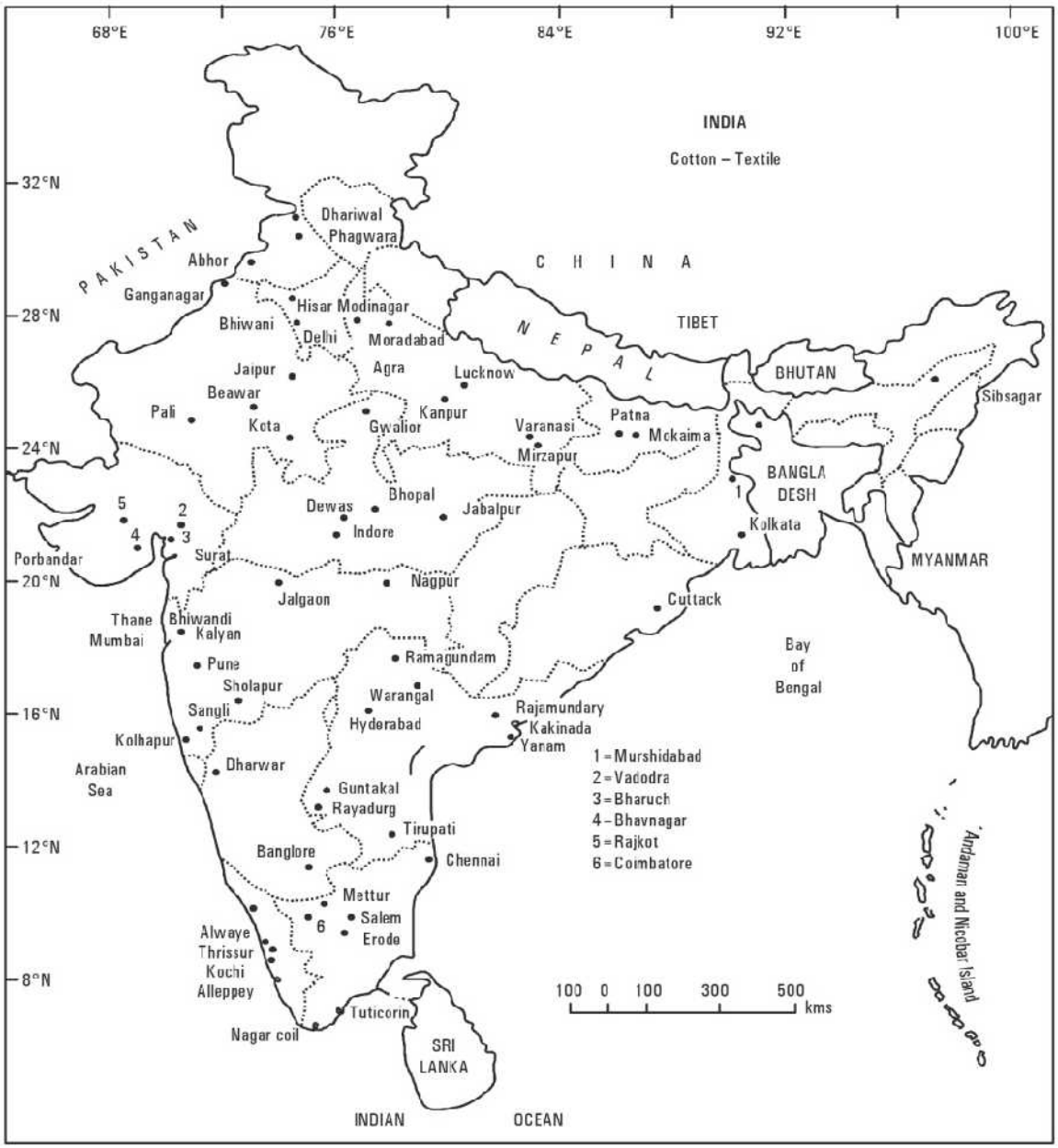

Fig. 10.29 – Cotton textile

***Table 10.45:** India–Statewise Production of Cotton Cloth*

	State/Union Territories	*Production (sq. metres)*	*Percentage of All India Production*
1.	Maharashtra	400,550	38.89
2.	Gujarat	355,745	34.54
3.	Tamil Nadu	65,850	6.40
4.	Punjab	56,850	5.53
5.	Madhya Pradesh	48,500	4.70
6.	Uttar Pradesh	32,850	3.20
7.	Rajasthan	28,880	2.80
8.	Puducherry	25,250	2.45
9.	Karnataka	8,500	0.82
10.	Kerala	6,850	0.67
	Total (All India)	**10,29,825**	**100.00**

Source: Data computed from the Statistical Abstracts, 2007 – 08.

It may be observed from **Table 10.45** that Maharashtra is the leading producer of cotton goods contributing about 39 per cent of the total production, followed by Gujarat (34.54 %), Tamil Nadu (6.4%), and Punjab (5.53 %). The other producers of cotton goods include Madhya Pradesh, Uttar Pradesh, Rajasthan, Puducherry, Karnataka and Kerala.

The main problems of cotton textile industries are (i) shortage of raw material, (ii) Obsolete machinery, (iii) erratic power supply, (iv) strikes and lockouts, (v) competition with synthetic fibres, and (vi) competition in the international market.

Iron and Steel Industry

Iron and steel is one of the oldest industries of India. Its history is more than 4000 years old. The famous iron pillar near Qutab Minar is dating back to 350 A.D. The first attempt to produce iron and steel on modern lines was made in 1830 at Porto Nova near Chennai (Madras). But it was not successful as charcoal was the main source of energy for the smelting of iron ore. The real progress in iron and steel industry was made in 1907 when J.N. Tata established the iron-smelting factory at Sakchi (former name of Jamshedpur). Tremendous progress in the iron and steel industry was made during the Second Five Year Plan (1956-61) when the Government of India established steel plants at Bhilai, Durgapur and Rourkela in collaboration with the Soviet, British, and German governments, respectively. The other important steel industries of India are located at Bhadravati, Salem, Vishakhapatnam, Vijainagar, Kalinganagar, Daitre and Dolvi **(Fig. 10.30)**.

The Damodar Valley is known as the Rhur Basin of India. It has several complexes of iron and steel, smelting, machine-building and fertilizer industries. The location of coal, iron-ore mines, copper limestone, manganese, chromite and major industrial places in the Damodar Valley have been shown in **Fig. 10.31**.

National Highways

The National Highways in India are developed and maintained by the Central Government. The National Highways of India have been shown in **Fig. 10.32**, while **Table 10.46** gives the main cities on the different National Highways.

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***Table 10.46**: Important National Highways of India*

National Highway	*Route*	*Length in km*
1	Delhi-Ambala-Jalandhar-Amritsar	456
1A	Jalandhar-Madhopur-Jammu-Srinagar-Baramulla-Uri	663
1B	Batote, Toda, Kishtwar,	274
2	Delhi-Mathura-Agra-Kanpur-Allahabad-Varanasi-Barh-Kolkata	
3	Agra-Gwalior-Shivpuri-Indore-Dhulia-Nasik-Thane-Mumbai	1161
4	Thane-Pune-Belgaum-Hubli-Bangalore-Ranipet-Chennai	1533
4A	Belgaum-Anmode-Ponda-Panaji	153
5	Bahargagora-Cuttack-Bhubaneshwar-Vishakhapatnam-Vijaiwada-Chennai	
6	Dhule-Nagpur-Raipur-Sambalpur-Baharagora-Kolkata	1645
7	Varanasi-Rewa-Jabalpur-Nagpur-Hyderabad-Bangalore-Madurai-Kanniyakumari	2369
8	Delhi-Jaipur-Ajmer-Udaipur-Ahmadabad-Vadodra-Mumbai	1428
9	Pune-Solapur-Hyderabad-Vijaiwada	791
10	Delhi-Fazilka	403
11	Agra-Bharatpur-Jaipur-Bikaner	582
12	Jabalpur-Bhopal-Kota-Bundi-Jaipur	890
13	Solapur-Chitradurga	491
14	Beawar-Sirohi-Radhanpur	450
15	Pathankot-Bhatinda-Bikaner-Jaisalmer	1526
21	Chandigarh-Rupnagar-Mandi-Kullu-Manali	323
22	Ambala-Kalka-Shimla-Narkanda-Rampur-Chini	462
24	Delhi-Bareilly-Lucknow	438
25	Lucknow-Kanpur-Jhansi-Shivpuri	319
28	Barauni-Muzaffarpur-Gorakhpur-Lucknow	570
31	Bakhtiyarpur-Siliguri-Nalbari-Aminagaon	1125
37	Goalpara-Guwahati-Kamargaon-Saikhoa Ghat	680
39	Numiligarh-Imphal-Palel	436
43	Raipur-Vizianagram	560
47	Salem-Coimbatore-Thiruvananthapuram-Kanniyakumari	640
52	Baihata-Charali-Tezpur-Lakhimpur-Sekhoaghat	850
54	Silchar-Aizawl	560
56	Lucknow-Varanasi	285

Golden Quadrilateral (GQ): The National Highways Development Project (NHDP) launched a massive programme in 1999 known as Golden Quadrilateral **(Fig. 10.33)**. The length of the different sectors has been given in **Table 10.47**.

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Table 10.47: *Length of Various Sections of the Golden Quadrilateral*

Name	*Length of sides of the Golden Quadrilateral in km*
Delhi-Mumbai	1419
Mumbai-Chennai	1290
Chennai-Kolkata	1684
Kolkata-Delhi	1453
Total	**5846**
	Length of Corridor
North-South Corridor, connecting Srinagar with Kanniyakumari	4000
East-West Corridor connecting Silchar with Porbandar	3300
Total	**7300**

Table 10.48: *Length of Railways in some of the States*

	State	*Length of Railway (in km per 1000 aq km)*
1.	Punjab	42.78
2.	West Bengal	41.85
3.	Bihar	30.82
4.	Uttar Pradesh	30.20
5.	Tamil Nadu	29.96
6.	Gujarat	28.73
7.	Assam	27.58
8.	Goa	20.72
9.	Andhra Pradesh	17.39
10.	Maharashtra	17.00

Table 10.49: *Indian Railway Zones and their Headquarters*

	Zone	*Date of Formation*	*Headquarters*
1.	Southern	14.04.1951	Chennai
2.	Central	05.11.1951	Mumbai (CST)
3.	Western	05.11.1951	Mumbai (Church Gate)
4.	Northern	14.04.1952	New Delhi
5.	North-Eastern	14.04.1952	Gorakhpur
6.	South-Eastern	01.08.1955	Kolkata
7.	Eastern	01.08.1955	Kolkata

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8.	North-Eastern Frontier	15.01.1958	Maligaon (Guwahati)
9.	South Central	02.10.1966	Secundrabad
10.	East Central	01.10.2002	Hajipur
11.	North-Western	01.10.2002	Jaipur
12.	East Coast	01.04.2003	Bhubaneshwar
13.	North Central	01.04.2003	Allahabad
14.	South-East Central	01.04.2003	Bilaspur
15.	South Western	01.04.2003	Hubli
16.	West Central	01.04.2003	Jabalpur

International Trade

The developed and wealthy countries of the world, with their aggressive market-led economies as well as access to productive new technologies and international markets, dominate the world economic system. At the other extreme, many of the countries of the developing world are locked in a cycle of national debt, rising population and unemployment. The state-managed economies of the former communist bloc began to be dismantled during the 1990s. At present, China and India are emerging as the major economic powers in the international trade. World trade acts as a stimulus to national economies, encouraging growth. Over the last three decades, as heavy industries have declined

services-banking, insurance, tourism, airlines, and shipping have taken an increasingly large share of world trade. Manufactured articles now account for nearly two thirds of world trade; raw materials and food make up less than a quarter of the total. The major exports and imports of India have been given in **Tables 10.50 and 10.51.**

***Table 10.50** : India – Commodity Composition of Exports (2006-07)*

	Commodity Group	*Percentage Share 2006-07*
I.	Primary Products	15.40
	(i) Agriculture and allied	10.20
	(ii) Ores and minerals	05.20
II.	Manufactured Goods	65.70
	(i) Engineering goods	20.70
	(ii) Gems and jewellery	15.10
	(iii) Textiles	14.50
	(iv) Chemicals and related products	11.60
	(v) Leather and leather goods	02.60
	(vi) Handicrafts including hand-made carpets	01.20
III	Petroleum-crude and products including coal	11.50
IV.	Others	07.40
	Total	**100.00**

Chapter Eleven

Population

Chapter Concepts

- Growth and density of population
- Sex-ratio and literacy rate
- Religious composition
- Scheduled Tribes and Scheduled Castes of India
- Human Development

India has the second largest population in the world after China. Its distribution is, however, most uneven.

The distribution of population is controlled directly or indirectly by the physical factors (terrain, topography, climate, soils, natural vegetation, minerals, etc.) and cultural milieu (socio-economic and cultural development). A brief description of the salient characteristics of Indian population has been given in the following.

Growth of Population

Growth of population is the rate of increase in the number of people living in a particular area between two given points of time. The net change between the two points of time is expressed in percentage and described as the growth rate of population. The decadal growth of population between 2001 and 2011 has been given in **Table 11.1**, while the percentage decadal growth of population in the selected states between 2001-2011 has been plotted in **Fig. 11.1 (Table 11.2)**.

Table 11.1: *India–Growth of Population*

Year	*Population*	*Decadal Growth %*	*Change in Decadal Growth%*	*Progressive Growth Rate over 1901*
1901	23,83,96,327	-	-	-
1911	25,20,93,390	5.75	-	5.75
1921	25,13,21,213	10.31	-6.05	5.42
1931	27,89,77,238	11.00	11.31	17.02
1941	31,86,60,580	14.22	3.22	33.67
1951	36,10,88,090	13.31	-0.91	51.47

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1961	43,92,34,771	21.64	8.33	84.25
1971	54,81,59,652	24.80	3.16	129.94
1981	68,33,29,097	24.66	-0.14	186.64
1991	84,64,21,039	23.87	-0.79	255.05
2001	1,02,87,37,436	21.54	-2.33	331.47
2011	1,210,193,422	17.64	-	-

Source: Census of India, 2011.

Table 11.2: *Selected States–Decadal Growth of Population between 2001-2011* ***(Fig. 11.1)***

State	*Decadal Growth Rate in Percentage*
1. Arunanchal Pradesh	25.92
2. Bihar	25.07
3. Jammu and Kashmir	23.71
4. Mizoram	22.78
5. Rajasthan	21.44
6. Madhya Pradesh	20.30
7. Uttar Pradesh	20.09
8. Sikkim	12.36
9. Kerala	4.86
10. Nagaland	0.47

Source: Census of India 2011

It may be seen from **Table 11.2** that the highest decadal growth of population between 2001 and 2011 was recorded in Arunachal Pradesh (25.92%) followed by Bihar (25.07%) , and Jammu and Kashmir (23.71%). The decadal growth rate in Mizoram was 22.78%, Rajasthan 21.44% and U.P. 20.09 percent. The lowest decadal growth of population was in Nagaland (0.47%) followed by Kerala 4.86 percent. The fast growth of population in the northern states of India is mainly because of the low level of literacy, unemployment and poor standard of living.

Density of Population

The density of population shows the land man ratio. It is calculated on the basis of total population divided by the total area of the country. The density of population of the different states and union territories of India as per the Census of 2011 has been shown in **Fig. 11.2**.

Table 11.3: *India: Statewise Density of Population 1991-2001*

Rank in 2001	*State/Union Territory*	*Density 2001*	*Density 2011*
1.	Delhi	9,340	11,297
2.	Chandigarh	7,900	9,252
3.	Puducherry	2,034	2,598
4.	Lakshadweep	1,895	2,013
5.	Daman & Diu	1,413	2,169

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6.	Bihar	881	1102
7.	West Bengal	903	1029
8.	Kerala	819	859
9.	Uttar Pradesh	689	828
10.	Dadra & Nagar Haveli	449	698
11.	Punjab	482	550
12.	Tamil Nadu	478	555
13.	Haryana	477	573
14.	Jharkhand	338	414
15.	Assam	340	397
16.	Goa	364	394
17.	Maharashtra	314	365
18.	Tripura	304	350
19.	Karnataka	275	319
20.	Andhra Pradesh	275	308
21.	Gujarat	258	308
22.	Odisha	236	269
23.	Madhya Pradesh	196	236
24.	Rajasthan	165	201
25.	Uttarakhand	159	189
26.	Chhattisgarh	154	189
27.	Meghalaya	103	132
28.	Jammu & Kashmir	100	124
29.	Himachal Pradesh	109	123
30.	Manipur	107	122
31.	Nagaland	120	119
32.	Sikkim	76	86
33.	Mizoram	42	52
34.	Andaman & Nicobar Islands	43	46
35.	Arunachal Pradesh	13	17
	INDIA	324	382

Source: Census of India-2011.

It may be seen from **Table 11.3** that among the larger states, Bihar has the highest density (1102 per sq km), followed by West Bengal (1029), Kerala (859) and Uttar Pradesh (828). Arunachal Pradesh has the lowest density (17 persons per sq km), followed by Mizoram (52), Sikkim (46) and Jammu and Kashmir (124 persons per sq km).

Among the Union Territories, Delhi with a density of 11,297 persons per sq km has the highest density of population, while Andaman and Nicobar Islands with a density of 46 persons per sq km has the lowest density.

Sex Ratio

Sex ratio has been defined as the number of females per thousand of males. Of all the demographic attributes of population, sex ratio is the most fundamental as it determines the reproductive potential, marital status, growth of population, work force, migration pattern, and the socio-economic relationship. The sex-ratio in India is highly skewed being **940:1000**. This is attributed to women's lower status in Indian society which has contributed to their higher mortality rate in all age groups.

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The sex ratio of the different states has been shown in **Fig. 11.3**, **Table 11.4** gives the sex ratio between 1901 to 2011.

It may be seen from **Table 11.4** that in 1901, there were 972 females per 1000 of males which declined to 927 in 1991. In 2001, the sex ratio was, 933/1000, showing an increase of six females per 1000 of males. In 2011, the sex ratio recorded a further increase, being 940:1000.

Table 11.4: *India–Sex Ratio:1901-2001*

Census Year	*Sex Ratio (Females Per 1000 males)*
1901	972
1911	964
1921	955
1931	950
1941	945
1951	946
1961	941
1971	930
1981	934
1991	927
2001	933
2011	940

Source: *Census of India-2011.*

It may be observed from **Fig. 11.3** that in 2011, the highest sex ratio was in Kerala (1048/1000), followed by Tamil Nadu (995), Andhra Pradesh (992) and Chhattisgarh (991). The lowest sex ratio was recorded in Haryana (877) followed by Punjab (893) and Jammu and Kashmir(883) **Fig. 11.3.**

Literacy Rate

Literacy rate is an important indicator of the prevailing socio-cultural development and political consciousness. Literacy, in fact, is the vehicle of socio-economic transformation as it facilitates the acquisition of specific skills, develops occupational competence, and accelerates the process of social transformation. The definition of literacy differs from country to country. In India, according to the Census of India 2011, a person above seven years of age who can read and write with understanding many language is known as a literate person. The literacy rate in the different states of India has been shown in **Fig. 11.4**, while the changing trends of literacy rate in India during the decadaes of post Independence (1951-2011) have been given in **Table 11.5.**

Table 11.5: *India–Literacy Rate: 1951-2011*

Census Year	*Persons %*	*Males%*	*Females%*
1951	18.33	27.16	8.86
1961	28.3	40.40	15.35
1971	34.45	45.96	21.97
1981	43.57	56.38	29.76
1991	52.21	64.13	39.29
2001	64.84	75.26	53.67
2011	74.04	82.10	65.46

Source: Census of India, 2001.

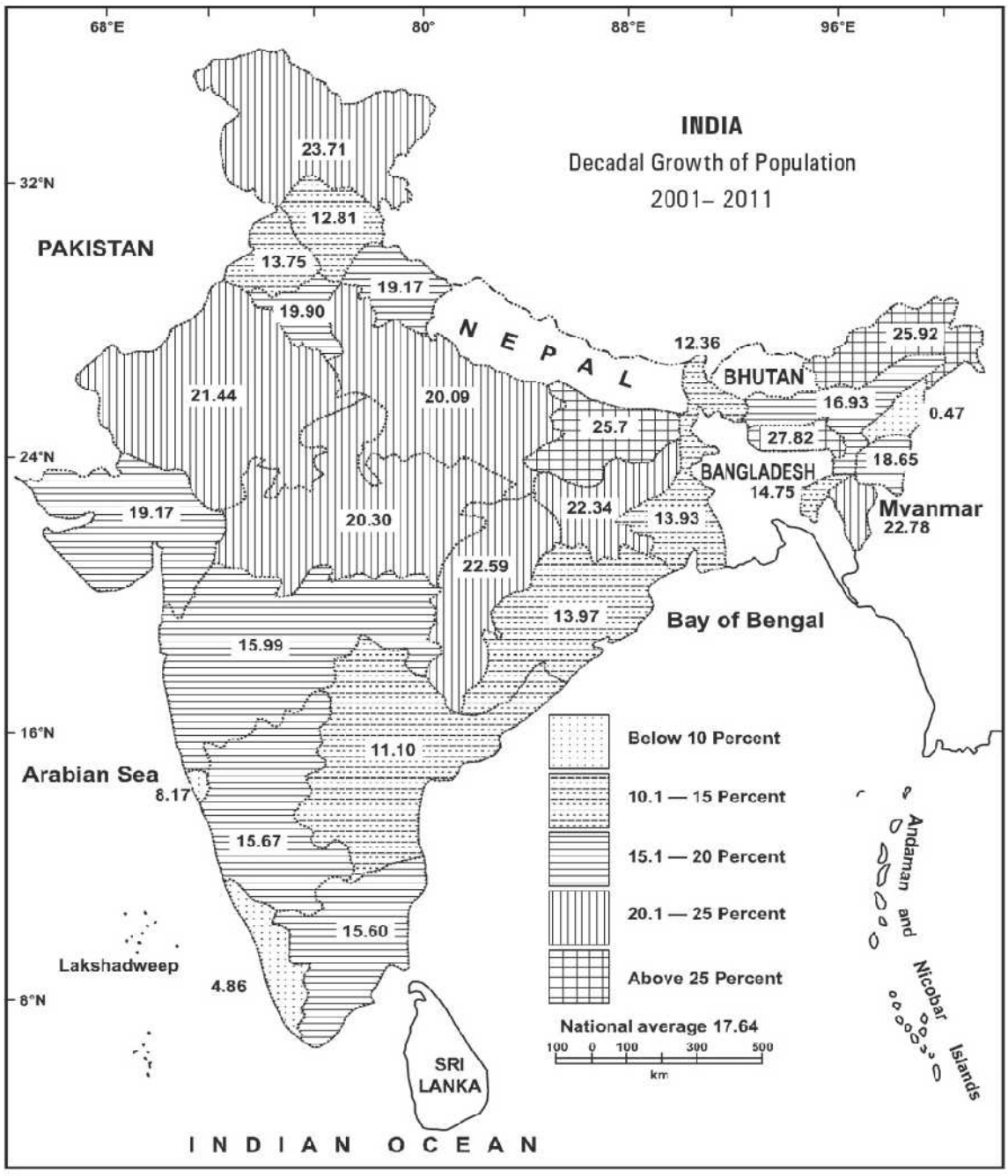

Fig. 11.1 – Percentage decadal growth of population 2001-2011

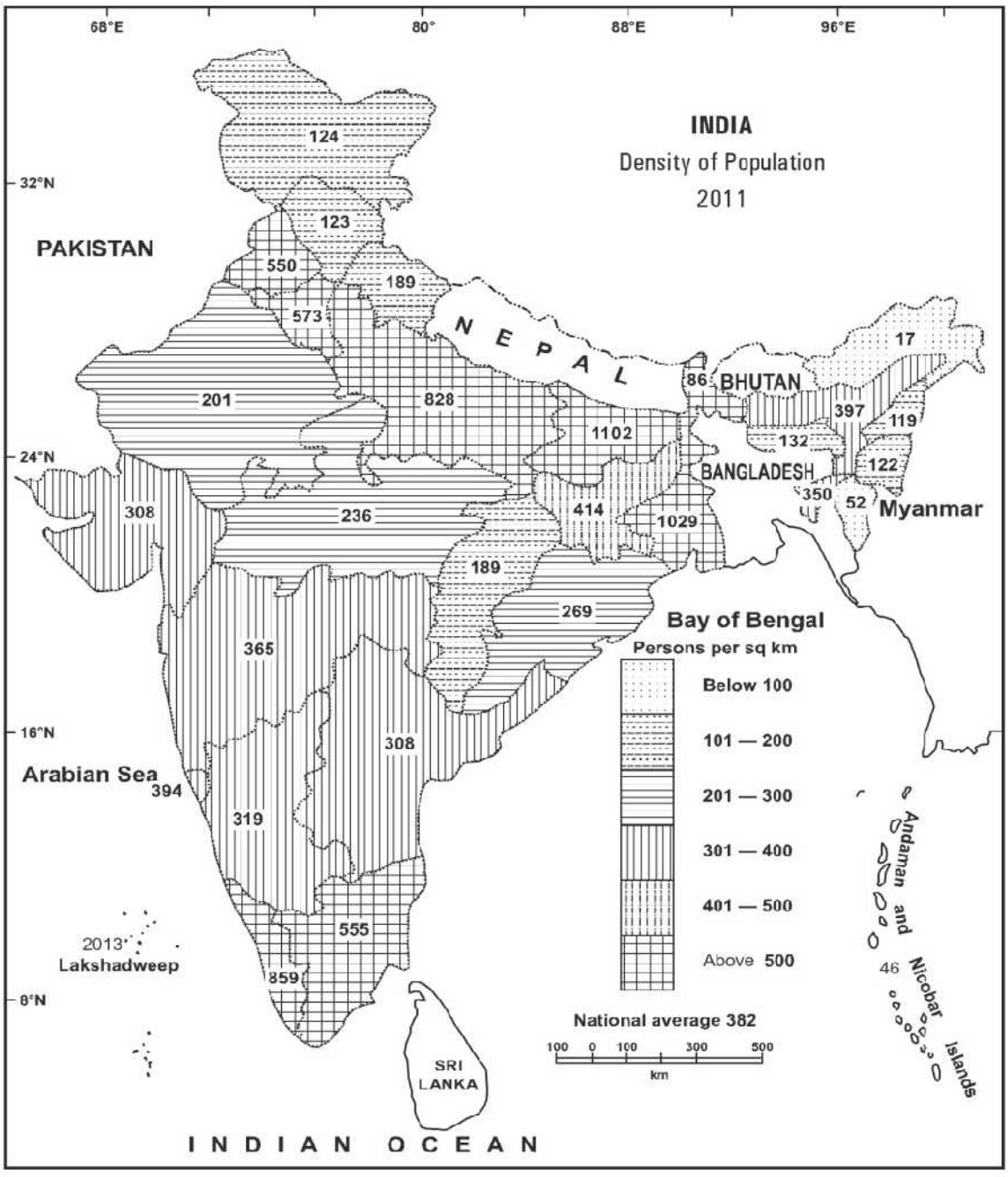

Fig. 11.2 – Density of Population 2011

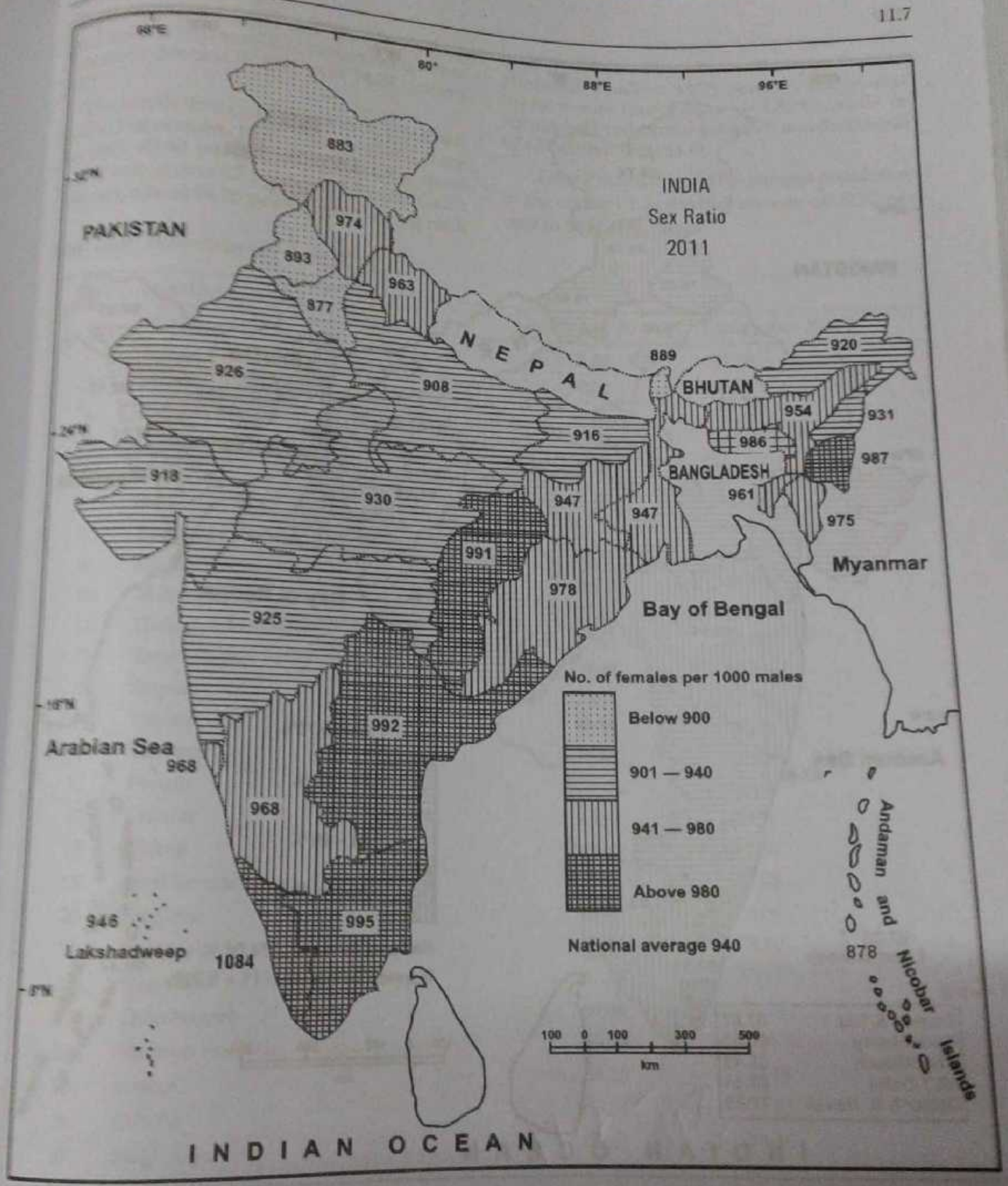

Fig. 11.3 – Sex - Ratio (2011)

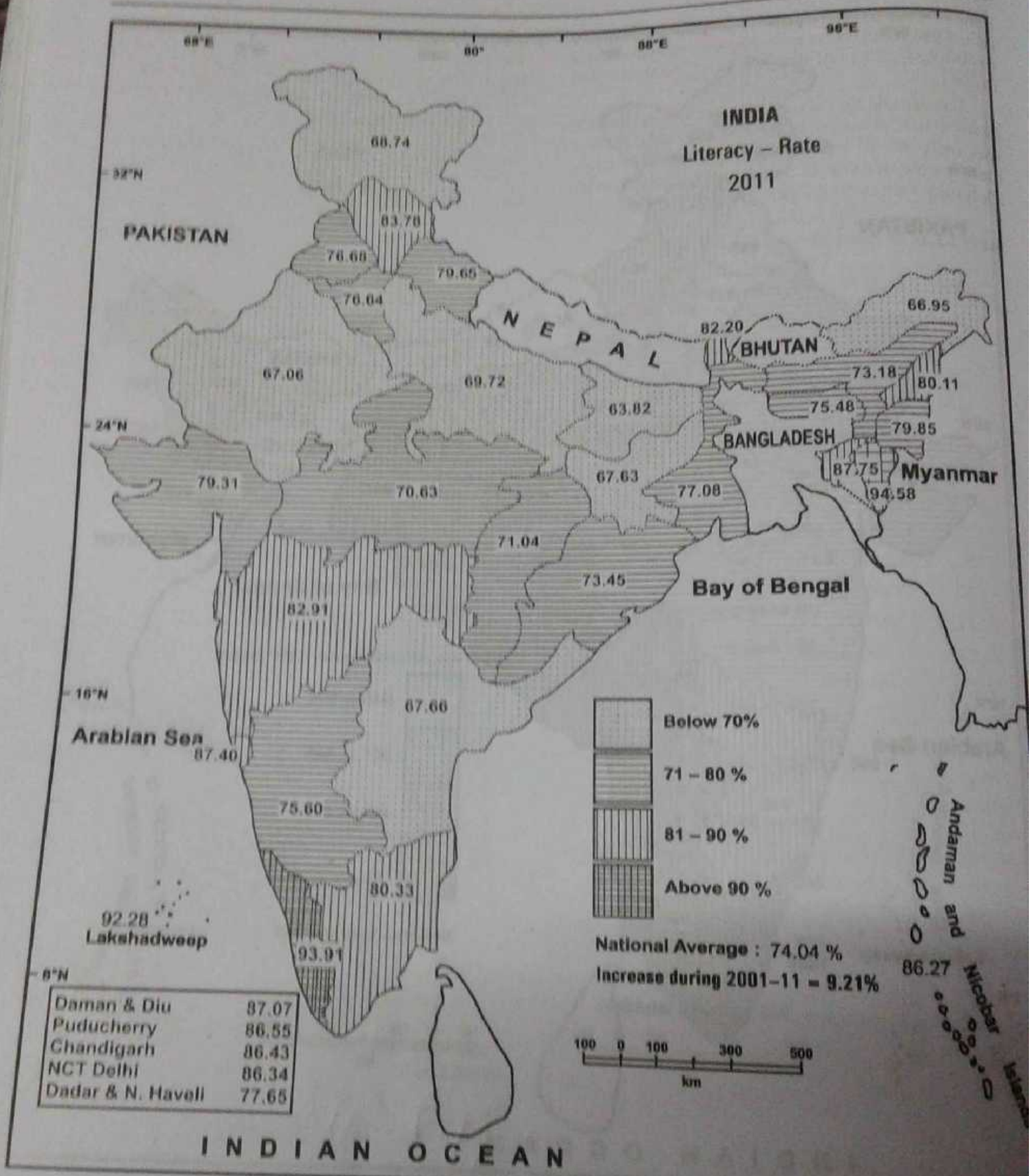

Fig. 11.4 – Effective Literacy Rate — 2011

It may be seen from **Table 11.5** that the literacy rate of India in 1951 was 18.33 percent which rose to about 65 per cent in 2001, and 74.04 percent in 2011.

The female literacy rate, however, remained lower to that of males. In 2011, the female literacy was only 65.40 percent as against the male literacy rate of over 82.1 percent, Mizoram with a leteracy rate of 94.85 percent got the first rank in 2011, followed by Kerala 93.11 percent and Himachal Pradesh 83.78 percent. The lowest literacy was found Bihar (63.82%) while in Arunachal Pradesh it was 66.95% and Jharkhand 67.63 percent **(Fig. 11.4)**.

Uttar Pradesh having the laregest population in the country has the literacy rate of 69.72 per cent in 2011 **(Fig. 11.4)**.

Table 11.6: *India–Literacy Rate 2011*

Rank	*State/Union Territory*	*Literacy Rate 2001 %*	*Literacy Rate 2011 %*
1.	Kerala	90.92	93.91
2.	Mizoram	88.49	94.58
3.	Lakshadweep	86.66	92.28
4.	Goa	82.01	87.40
5.	Chandigarh	81.94	86.43
6.	Delhi	81.67	86.34
7.	Andaman and Nicobar Islands	81.30	
8.	Puducherry	81.24	86.55
9.	Daman & Diu	78.18	87.07
10.	Maharashtra	77.27	82.91
11.	Himachal Pradesh	77.13	83.78
12.	Tamil Nadu	73.47	80.33
13.	Tripura	73.16	87.75
14.	Uttarakhand	72.28	79.65
15.	Manipur	70.87	79.85
16.	Punjab	69.95	76.68
17.	Gujarat	69.97	79.31
18.	Sikkim	69.69	82.20
19.	West Bengal	69.22	77.08
20	Haryana	68.60	76.64
21.	Karnataka	67.04	75.60
22.	Nagaland	67.11	80.11
23.	Chhattisgarh	64.66	71.04
24.	Madhya Pradesh	63.74	70.63
25.	Assam	64.28	73.18
26.	Odisha	63.61	73.45
27.	Meghalaya	63.61	75.48
28.	Andhra Pradesh	61.11	67.66
29	Rajasthan	61.03	67.06
30.	Dadra & Nagar Haveli	57.63	77.65

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31.	Uttar Pradesh	57.36	69.72
32.	Jammu & Kashmir	54.46	68.74
33.	Arunachal Pradesh	54.74	66.95
34.	Jharkhand	54.13	67.63
35.	Bihar	47.53	63.82
	India	**65.38**	**74.04**

Source: Census of India, 2001 and India 2011.

Rural and Urban Population

India is essentially a country of rural population. About 70.5 per cent of the total population is rural in character and only 29.5 per cent was urban in 2011. The changing pattern of rural and urban population during the last century has been given in **Table 11.7**. It may be observed from **Table 11.7** that in 1901 only 10.8 per cent of the total population was urban which rose to about 29.5 per cent in 2011.

***Table 11.7:** India–Rural and Urban Population:1901-2011*

Census Year	*Rural Population (in million)*	*Urban Population (in million)*	*Percentage of Total Rural Population*	*Percentage of Total Urban Population*
1901	213	26	89.2	10.8
1911	226	26	89.7	10.3
1921	223	28	88.8	11.2
1931	246	33	88.0	12.0
1941	275	44	86.1	13.9
1951	299	62	82.7	17.3
1961	360	79	82.0	18.0
1971	439	109	80.1	19.9
1981	524	159	76.7	23.3
1991	629	218	74.3	25.7
2001	743	286	72.2	27.8
2011	853	357	70.5	29.5

Source: Census of India-2011.

Religious Composition

Religion like language is a symbol of group identity and a cultural rallying point. All societies, irrespective of their levels of economic development have value systems, common beliefs, understandings, and expectations which unite their people.

India is a multi-religious country. It is the birth place of Hinduism, Buddhism, Jainism, and Sikhism. Besides, there are followers of Judaism, Christianity, Islam, and Zoroastrianism (Parsis), who came in India from the countries of South West and Central Asia. The proportion of different religious groups in India has been given in **Table 11.8**.

Table 11.8: *Religious Composition of India, 2001*

Religious Group	*Population (million)*	*% of Total Population*
Hindus	827.0	80.5
Muslims	138.2	13.5
Christians	24.1	2.3
Sikhs	19.2	1.9
Buddhists	8.0	0.9
Jains	4.2	0.4
Others	6.6	0.5

Source: Census of India, 2001.

It may be seen from **Table 11.8** that Hindus with 80.5 per cent is the largest majority in the country. Their concentration, however, varies from state to state and region to region.

Muslims with 13.5 per cent of the total population is the largest minority, followed by Christians (2.3%), Sikhs (1.9%), Buddhists (0.9 %) and Jains (0.4 %). There are numerous scheduled tribes, many of whom follow the tribal religion. Various characteristics of different religious groups have been given in **Table 11.9**.

Table 11.9: *India – Salient Characteristics of Different Religious Groups*

Religious Community	*Population %*	*Growth (1991 2001)*	*Sex Ratio (Child per thousand)*	*Total Sex Ratio*	*Literacy %*	*Work Participation %*
Hindu	80.46 %	20.30 %	925	931	65.10 %	40.40 %
Muslim	13.43 %	36.00 %	950	936	59.10 %	31.30 %
Christian	2.34 %	22.60 %	964	1009	80.30 %	39.70 %
Sikh	1.87 %	18.20 %	786	893	69.40 %	37.70 %
Buddhist	0.77 %	18.20 %	942	953	72.70 %	40.60 %
Jain	0.41 %	26.00 %	*70	940	94.10 %	32.90 %
Others	0.65 %	21.54 %	976	992	47.00 %	48.40 %

Source: Census of India 2001.

Languages

India is a multi-ethnic multi-lingual country. According to the Census of India, there are 187 languages spoken by different social groups.

Out of these 94 languages are spoken by less than 10,000 people. The Indian languages belong to the following four linguistic groups:

1. The Indo-European Family (Arya): About 73 per cent of the Indian population speak language of Aryan family.
2. The Dravidian Family–Dravida (20%).
3. The Austric Family Nishada (4.5%).
4. The Sino-Tibetan Family–Kirata (2.5%).

The distribution of the main languages in the various states has been given in **Table 11.10**.

Table 11.10: *Indian Languages*

Family	*Sub-Family*	*Branch/Group*	*Speech Areas*
Austric Nishad (1.50%)	Austro-Asiatic	Mon-Khmer	Meghalaya, Nicobar Islands
	Austro-Asiatic	Munda	Assam, Bihar, Chhattisgarh, Jharkhand, Madhya Pradesh, Maharashtra, Odisha, West Bengal, Outside India
Dravidian (Dravida) 22%		South Dravidia	Tamil Nadu, Karnataka, Kerala
		Central Dravidia	Andhra Pradesh, Chhattisgarh, Jharkhand, Madhya Pradesh, Odisha
		North Dravidian	Bihar, Madhya Pradesh,Odisha, West Bengal
Sino-Tibetan (Kirata) 0.85%	Tibeto-Myanmari	Tibeto-Himalayan	Jammu and Kashmir, Himachal Pradesh, Sikkim
	Siamese-Chinese	Asssami-Myanamari	Assam, Manipur, Meghalaya, Mizoram, Nagland, Tripura
Indo-European (Aryan) 74%	Indo-Aryan	Iranian	Outside India
		Dardic	Jammu & Kashmir
		Indo-Aryan	Assam, Bihar, Chhattisgarh, Goa, Gujarat, Haryana, Himachal Pardesh, Jammu & Kashmir, Jharkhand, Madhya Pradesh, Odisha, Punjab, Uttar Pradesh, Uttarakhand, Maharashtra, West Bengal

Source: Rawat Publications, Jaipur, *Social Geography of India, Ahmad, A., 1999.*

Major Scheduled Tribes of India

Scheduled Tribes

The scheduled tribes given in the Constitution of India constitute about 8.2 per cent of the total population of the country (2001). They belong to the different racial, ethnic, linguistic, religious and cultural groups. Indian scheduled tribes are mostly occupying the areas of isolation and relative isolation in the hilly, forest and mountainous areas of the country.

The scheduled tribes are essentially the indigenous people. They often been termed as the people of the *'Fourth World'*. They are the victims of the past and present colonialism. They have maintained a close relationship with land and forests. In their society, there exists a co-operative attitude of give and take, a respect for the Earth and the life it supports. Their philosophy of life is *'From everybody according to his capacity, to everyone according to his needs.'* The important tribes of different states and union territories have been given in Fig. 11.5.

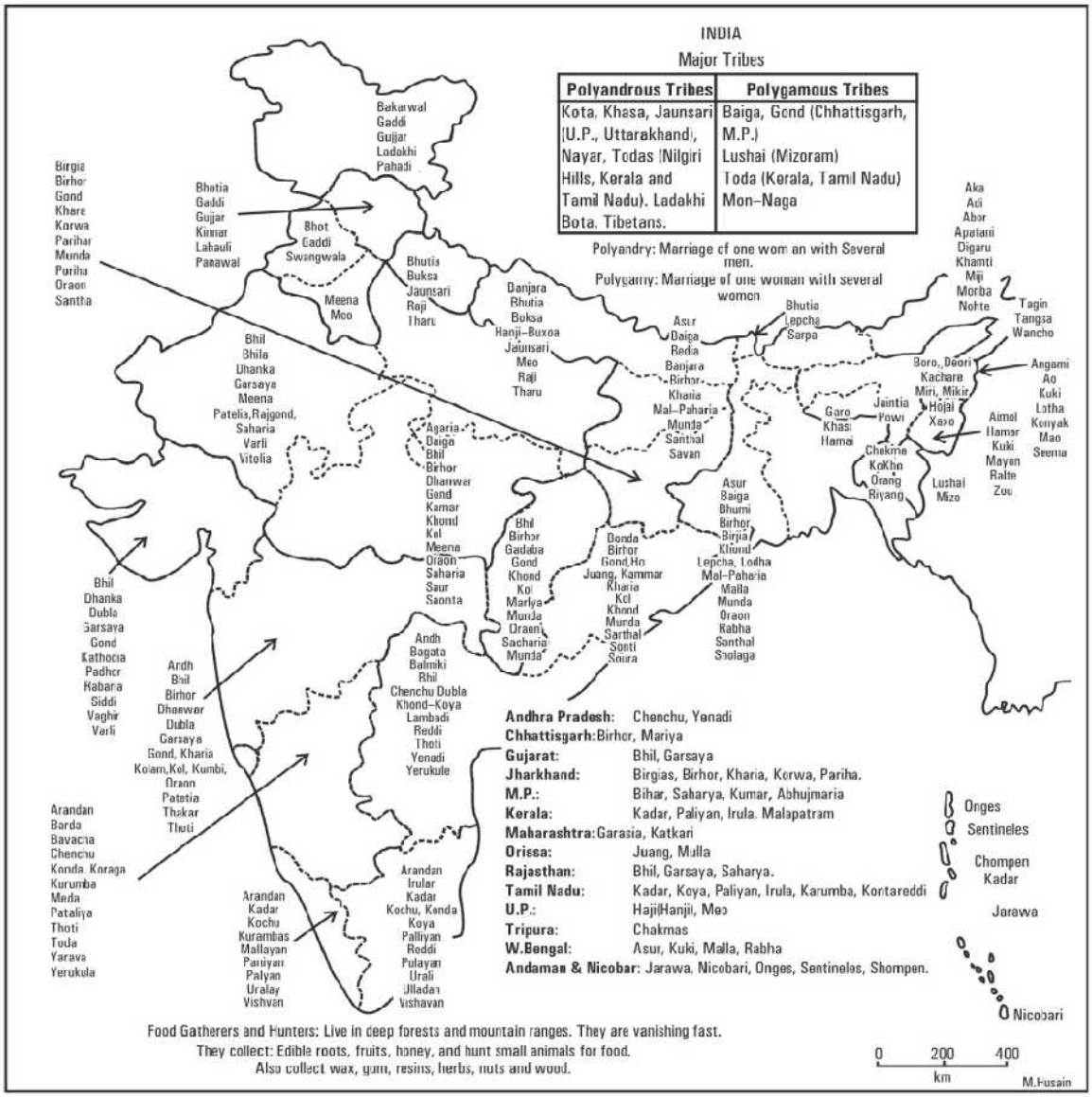
INDIA
Major Tribes
Polyandrous Tribes
Kota, Khasa, Jaunsari (U.P., Uttarakhand), Nayar, Todas (Nilgiri Hills, Kerala and Tamil Nadu). Ladakhi Bota, Tibetans.
Polygamous Tribes
Baiga, Gond (Chhattisgarh, M.P.)
Lushai (Mizoram)
Toda (Kerala, Tamil Nadu)
Mon-Naga
Polyandry: Marriage of one woman with several men.
Polygamy: Marriage of one woman with several women
Andhra Pradesh: Chenchu, Yenadi
Chhattisgarh: Birhor, Mariya
Gujarat: Bhil, Garsaya
Jharkhand: Birgias, Birhor, Kharia, Korwa, Pariha.
M.P.: Bihar, Saharya, Kumar, Abhujmaria
Kerala: Kadar, Paliyan, Irula, Malapatram
Maharashtra: Garasia, Katkari
Orissa: Juang, Mulla
Rajasthan: Bhil, Garsaya, Saharya.
Tamil Nadu: Kadar, Koya, Paliyan, Irula, Karumba, Kontareddi
U.P.: Haji/Hanjil, Meo
Tripura: Chakmas
W.Bengal: Asur, Kuki, Malla, Rabha
Andaman & Nicobar: Jarawa, Nicobari, Onges, Sentineles, Shompen.
Onges
Sentineles
Chompen
Kadar
Jarawa
Nicobari
Food Gatherers and Hunters: Live in deep forests and mountain ranges. They are vanishing fast.
They collect: Edible roots, fruits, honey, and hunt small animals for food.
Also collect wax, gum, resins, herbs, nuts and wood.
0 200 400
km
M.Husain

Fig. 11.5 – Major tribes of India

Andaman and Nicobar Islands: Andamanese, Chompens, Jarawa, Nicobari, Onges, and Sentineles.

Andhra Pradesh: Andh, Bagata, Balmiki, Bhidhu, Bhil, Chenchu, Dora, Dubla, Gadaba, Gond, Jatapu, Kammara, Konda, Konda-Reddis, Khonds, Kotias/Kotiya, Koya, Kulia, Kutunayakan, Lambadi, Malis, Manne-Dora, Nakha-Dora, Nayaks, Porja, Pradhan, Reddis, Reddi-Doras, Rona/Rena, Sabra, Sugalis, Thoti, Valmiki, Yanadia, Yenadi, Yerukula.

Arunachal Pradesh: Abore, Adi, Aka, Apatani, Dafla, Digaru, Gomba, Khamti, Miji, Mishmi, Monba, Nokte, Singhpo.

Assam: Boro, Chakma, Dimsa, Devari, Hoja, Hozai, Kachari, Lalung, Mikir, Miri, Xaxa.

Bihar: Asur, Baiga, Banjara, Bedia, Binjhia, Birhor, Birjia, Chero, Chik, Gond, Ho, Karmali, Kharia, Kherwar, Khond, Kora, Korwa, Lohar, Mahli, Mal-Paharia, Munda, Oraon, Parhaiya, Santhal, Paharia, Sauria, Savar.

Gujarat: Bhil, Dhanka, Dubla, Garsaya, Gond, Kathodia, Rabaria, Siddi, Vaghir, Varli.

Himachal Pradesh: Bhot, Bhotia, Gaddi, Gujjar, Kanaura, Kinnar, Lahauli, Lamba, Pangwal, Sawangl.

Jammu and Kashmir: Bakarwal, Budhists of Ladakah, Gaddi, Gujjars, and Pahadi.

Karnataka: Arandan, Barda, Bamcha, Bavacha, Bhil, Chodhara, Chenchu, Dhanka, Dhodia, Dubla, Ekliga, Godalu, Gamta, Hasadaru, Hakki, Kadar, Kaikuruba, Kathodi, Kokna, Kolidhor, Koya, Koruba, Kudia, Kaniyan, Kuruman, Kota, Koraga, Konda-Reddi, Konda-Kakush, Kammara, Koraga, Kurumba, Malaikudi, Maleru, Meda, Marti, Mudugar, Malaikandi, Madian, Naikda, Paliyar Pardhi, Patalia, Pomla, Porama, Pulayan, Puniyan, Rathawa, Ragond, Solga, Soligaru, Thoti, Toda, Varava, Varli, Vitolia, Yerawa.

Kerala: Arandan, Erulaj, Eravallan, Kadar, Kannikar, Kochuvelan, Kadiyan, Kammara, Kahunayakan, Kochu, Kondakakus, Koraga, Kota, Kudia, Kurambas, Korichachhan, Kuruman, Malai, Mallayan, Mannar, Malai-Kandi, Matri, Pallyan, Palliyar, Paniyan, Palyan, Pulayan, Puniyan, Urali/Uralay Ulladana, Vishavan.

Madhya Pradesh: Agariya, Andh, Baiga, Bhil, Bhumia, Birhor, Biyar, Chanwar, Dhanwar, Damor, Gadaba, Garasia, Gond, Kamar, Keer, Khairwar, Khond, Kol, Korwa, Meena, Nagasia, Nat, Nihal, Oraon, Panika, Pao, Patika, Pradhan, Saharia, Saonta, Saur, Sawar.

Manipur: Aimol, Hamar, Kuki, Mayon, Ralte, Zou.

Meghalaya: Garo, Hamar, Jaintia, Khasi, Powi.

Mizoram: Lushai, Mizo, Maat, Paki.

Nagaland: Angami, Ao, Konyak, Kuki, Lotha, Mikir, Mon, Rengma, Sema.

Punjab: Bhot, Bodh, Gaddi, Swangwala.

Odisha: Bagatta, Banjara, Bathudi, Bauga, Bharua, Bhotada, Bhumiya, Bhuyan, Bharua, Binjhal, Birher, Birhor, Chenchu, Dal, Desua, Gondia, Gond, Kora, Ho, Juang, Kammar, Kharia, Khond, Kisan, Kol, Koli, Konda, Kotia, Kuli, Kond, Kolha, Lodh, Lohar, Madia, Mahali, Mirdha, Munda, Oraon, Paitia, Parenga, Pondo, Poraja, Rajor, Shabar, Santhal, Sonti, Soura.

Rajasthan: Andh, Barda, Bavacha/Bamcha, Bhaina, Bhattra, Bhil, Bhila, Bhujiya, Binjhwar, Birhul, Charan, Chodhara, Dhanka, Dhanwar, Dhodia, Dhor Dubla, Gadaba, Gamit, Garsaya, Gond, Halbar or Halbi, Kamar, Kandh, Kathodi or Katkari, Kaudhri, Kharia, Kharwar, Kokna, Kokli, Kol, Koli, Kolam, Korku, Korwa, Koya, Kukka, Kunbi, Kuwar, Malhar, Meena, Naikda, or Naika, Nagasia, Nihal, Oraon, Padhar, Parja, Patelia, Paura-Bhils, Pomla, Pradhan, Rathawa, Rawri, Saharia, Saonto, Sawar, Siddi, Thakur/ Thakar, Thoti, Varli, Vitolia.

Tamil Nadu: Aranadan, Auidian, Eravalana, Erulia, Irular, Kadar, Kakush, Kammard, Kaniyan, Kochu, Konda, Konda-Reddy, Koraga, Kota, Koya, Kudia, Kulayan, Kochuvelan, Kuruman, Kurumba, Malai-Aryan, Malsar, Malikindi, Malyali, Malyan Mannan, Mudugaar, Muthuran, Paliyar, Paniyan, Palliyan/Pulliyan, Reddi, Sholga, Uralay, Ulladan, Urali, Vishvan.

Uttar Pradesh: Banjara, Bhoksa, Bhotia, Buxa, Hanji, Jaunsari, Kanjar, Raji, Sainsi, Tharu.

West Bengal: Asur, Baiga, Badia, Banjara, Baraik, Bhumij, Birhor, Birjia, Bhoomiji, Bhutia, Cheo, Chic, Chakma, Garo, Gond, Ho, Hajang, Khond, Kora, Karmali, Kharwar, Khund, Kisan, Korwa, Lepcha, Lodha or Kheria, Lepcha, Lohara, Magh, Mahli, Malpaharia, Mahali, Malla, Mech, Mru, Munda, Oraon, Rabha, Santhal, Sauria, , Savar, Sholaga.

Hunting Tribes of India

In the mountainous and forest areas still there are hunting tribes in India. The statewise classification of hunting tribes has been shown in **Fig. 11.6**.

Andhra Pradesh: Chenchu, Yenadi

Chattisgarh: Birhor, Maria/ Mariya

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Jharkhand: Birjias, Birhor, Kharia, Karwa

Kerala: Irula, Kadar, Korwa, Kuramba, Malapatram, Paliyan

Maharashtra: Garsaia, Karkaria, Kolam, Maria-Gond

Madhya Pradesh: Abhujmaria, Birhor, Kamar, Saharya

Odisha: Birhor, Juang, Kharias, Malla, Sauria

Rajasthan: Bhil, Garsaya, Saharya

Tamil Nadu: Irula, Kadar, Konta-Reddi, Koya, Kurumba, Paliyan

West Bengal: Asur, Kuki, Malla, Rabha, Toto

Andaman & Nicobar Islands: Jarawa, Nicobari, Onges, Sentinels, Shompen

Polyandrous Tribes

Kota, Khasa, Jounsari, (U.P. and Uttarakhand), Nayar, Todas (Nilgiri Hills-Kerala and Tamil Nadu), Bota-Tibetans (Ladakh-J & K).

Polygamous Tribes

Baiga (Chhattisgarh, M.P.), Gond (Chhattisgarh, Madhya Pradesh), Lushai (Mizoram), Toda (Kerala, Tamil Nadu), Mon (Nagaland).

Economic Classification of Tribes

On the basis of technological achievements into consideration, Majumdar has attempted an economic classification of Indian tribes.

1. **Tribes hunting in forests**: The main tribes engaged in hunting in India are Chenchu and Chandi of Andhra Pradesh, Kadar, Malapatram and Kurumba of Kerala, Paliyan of Tamil Nadu, and Onge, Jarawa, Senteneles of Andaman and Nicobar Islands. The Raji of Uttar Pradesh, Hill Garo of Meghalaya, Birhor, Korwa, Hill-Kharia of Chotanagpur, and Juang of Odisha.

2. **Tribes engaged in hilly cultivation (Shifting Cultivation or Jhuming)**: Most of the tribes living in the hilly areas of Assam, Arunachal Pradesh, Meghalaya, Mizoram, Manipur, Nagaland and Tripura are dependent on shifting cultivation (*Jhuming*). Some tribes of Odisha, Asur, Gond, Baiga, Munda, of Madhya Pradesh are also engaged in this type of cultivation. Apart from shifting cultivation, these tribes are also engaged in cottage industries.

3. **Tribes engaged in cultivation in plain areas**: Bodo, Miri, Xaxa of Assam, Gonds of Chhattisgarh and Jharkhand.

4. **Simple artisan tribes**: Asurs of Bihar, Agariya of Madhya Pradesh, Kolam of Maharashtra are traditional mat- weavers, and the Irula of Tamil Nadu make beautiful mats and baskets on bamboo.

5. **Pastoral tribes**: Bakarwals, Gaddis (Jammu & Kashmir and Himachal Pradesh), Maldhan (Gujarat), Todas (Nilgiri Mountains in Kerala and Tamil Nadu), Nageshia of Madhya Pradesh, Maldhan of Gujarat. Some of these tribes trade milk, while the others rear cattle like sheep, goats for selling them in the market.

6. **Tribes living as folk artists**: There are some tribes who earn their livelihood by performing dances, acrobatics, snake charmers, etc., and hence they are termed as '***folk-artists***'. The Nuts (Nats), and Saperas of Uttar Pradesh are good examples of this category. The Mundupptu of Odisha, are expert acrobats, the Kota of Tamil Nadu are snake charmers.

7. **Agricultural and non-agriculrural labour oriented tribes**: Among the tribes engaged in agriculture labour are those which are traditionally agriculturists, but due to their landlessness they work as agricultural labour on others land. According to one estimate about 20 per cent of the total tribal population is engaged in agriculture as wage earners. Non-agricultural tribal labour force include those tribals who are working in local factories and mines of Bihar, Chhattisgarh, Jharkhand, Madhya Pradesh, Odisha, West Bengal, etc. and tea plantation in Assam and West Bengal.

8. **Tribes engaged in service and trade**: Comparatively, a small percentage of the tribal population is engaged in government and semi-government jobs. Tribes in this category include the Meenas of Rajasthan, Khasi, Mizo and Nagas of North-East India.

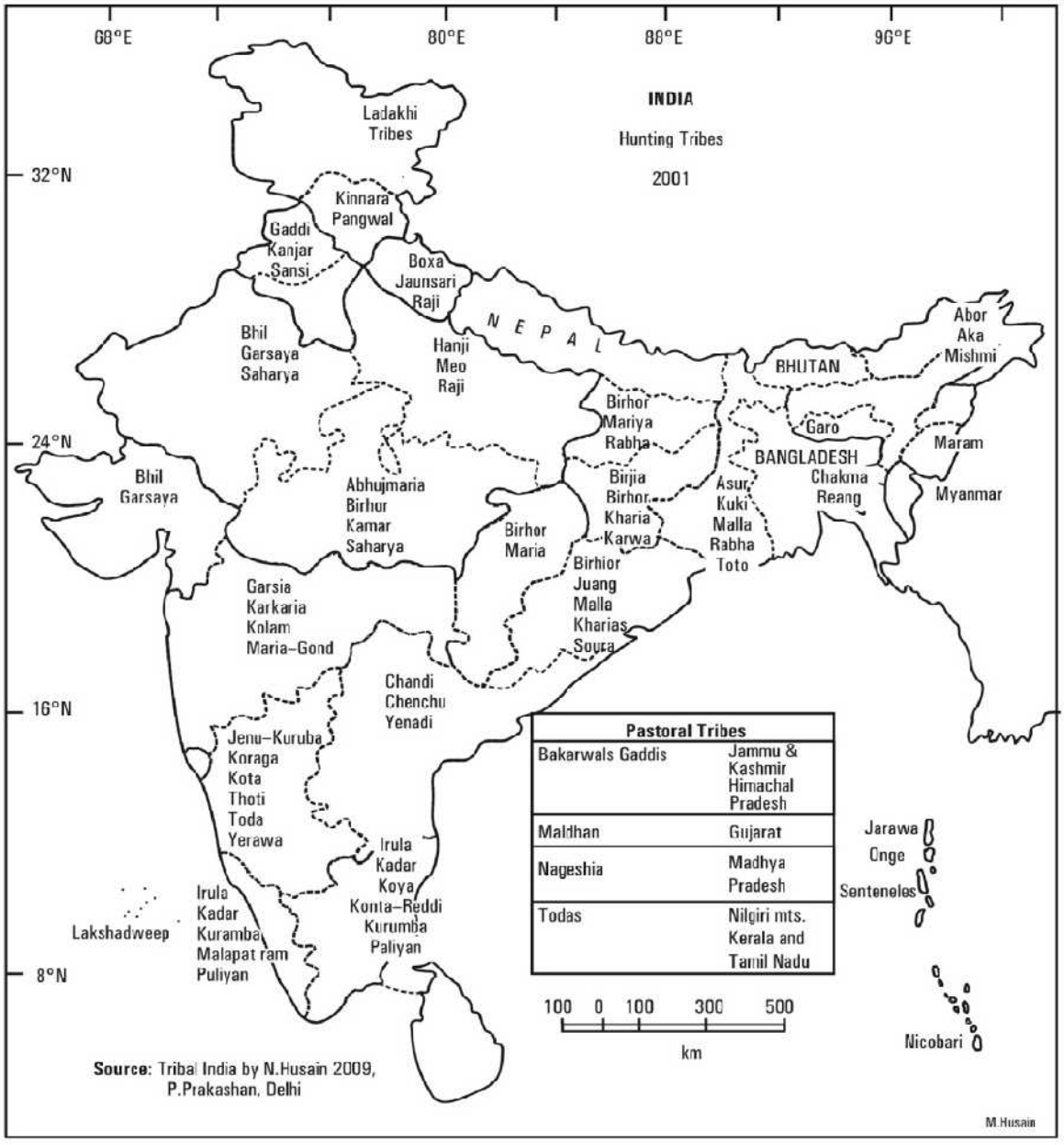

Fig. 11.6 – Hunting tribes of India.

Table 11.11: *India–Scheduled Castes and Scheduled Tribes, 2001*

India/States/ Union Territory	*Total Population*	*Scheduled Caste Population (000)*	*Scheduled Caste, Percentage of Population*	*Scheduled Tribe Population (000)*	*Scheduled Tribe Percentage of total Population*
INDIA	**1,028,610**	**166,636**	**16.20**	**84,326**	**8.20**
1. Jammu and Kashmir	10,144	770	7.59	1,106	10.90
2. Himachal Pradesh	6,078	1,502	24.72	245	4.02
3. Punjab	24,359	7,029	28.85	0	0.00
4. Chandigarh	901	158	17.50	0	0.00
5. Uttarakhand	8,489	1,517	17.87	256	3.02
6. Haryana	21,145	4,091	19.35	0	0.00
7. Delhi	13,851	2,342	16.92	0	0.00
8. Rajasthan	56,507	9,694	17.16	7,098	12.56
9. Uttar Pradesh	166,198	35,148	21.15	108	0.06
10. Bihar	82,999	13,148	15.72	758	0.91
11. Sikkim	541	27	5.02	111	20.60
12. Arunachal Pradesh	1,0986	6	0.56	705	64.22
13. Nagaland	1,990	0	0.00	1,774	89.15
14. Manipur	2,167	60	2.77	741	34.22
15. Mizoram	8890	0	0.03	839	94.50
16. Tripura	3,199	556	17.37	993	31.05
17. Meghalaya	2,319	11	0.48	1,993	85.94
18. Assam	26,656	1,826	6.85	3,309	12.41
19. West Bengal	80,176	18,453	23.02	4,407	5.50
20. Jharkhand	26,946	3,189	11.84	7,087	26.30
21. Odisha	36,805	6,082	16.53	8,145	22.13
22. Chhattisgarh	20,834	2,419	11.61	6,617	31.76
23. Madhya Pradesh	60,348	9,155	15.17	12,233	20.27
24. Gujarat	50,671	3,593	7.09	7,481	14.76
25. Daman and Diu	158	5	3.06	14	8.85
26. Dadra and Nagar Haveli	220	4	1.86	137	62.24
27. Maharashtra	96,879	9,882	10.20	8,577	8.85
28. Andhra Pradesh	76,210	12,339	16.19	5,024	6.59
29. Karnataka	52,851	8,564	16.20	3,464	6.55
30. Goa	1,348	24	1.77	1	0.04
31. Lakshadweep	61	0	0.00	57	94.51
32. Kerala	31,841	3,124	9.81	364	1.14
33. Tamil Nadu	62,406	11,858	19.00	651	1.01
34. Puducherry	974	158	16.19	0	0.00
35 Andaman & Nicobar Islands	356	0	0.00	29	8.27

Source: Census of India, 2001.

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It may be seen from **Table 11.11** that the highest percentage of tribal population is found in Lakshadweep (94.51%) followed by Mizoram (94.50%), Nagaland 89.15% and Meghalaya 86%. The states of Arunachal Pradesh and the Union Territory of Dadra and Nagar Haveli also have more than 62 per cent of their population as tribal. Contrary to this, the states of Goa, Haryana, Punjab and Uttar Pradesh have less than 0.1 per cent of their population as the tribal population **(Fig. 11.7)**.

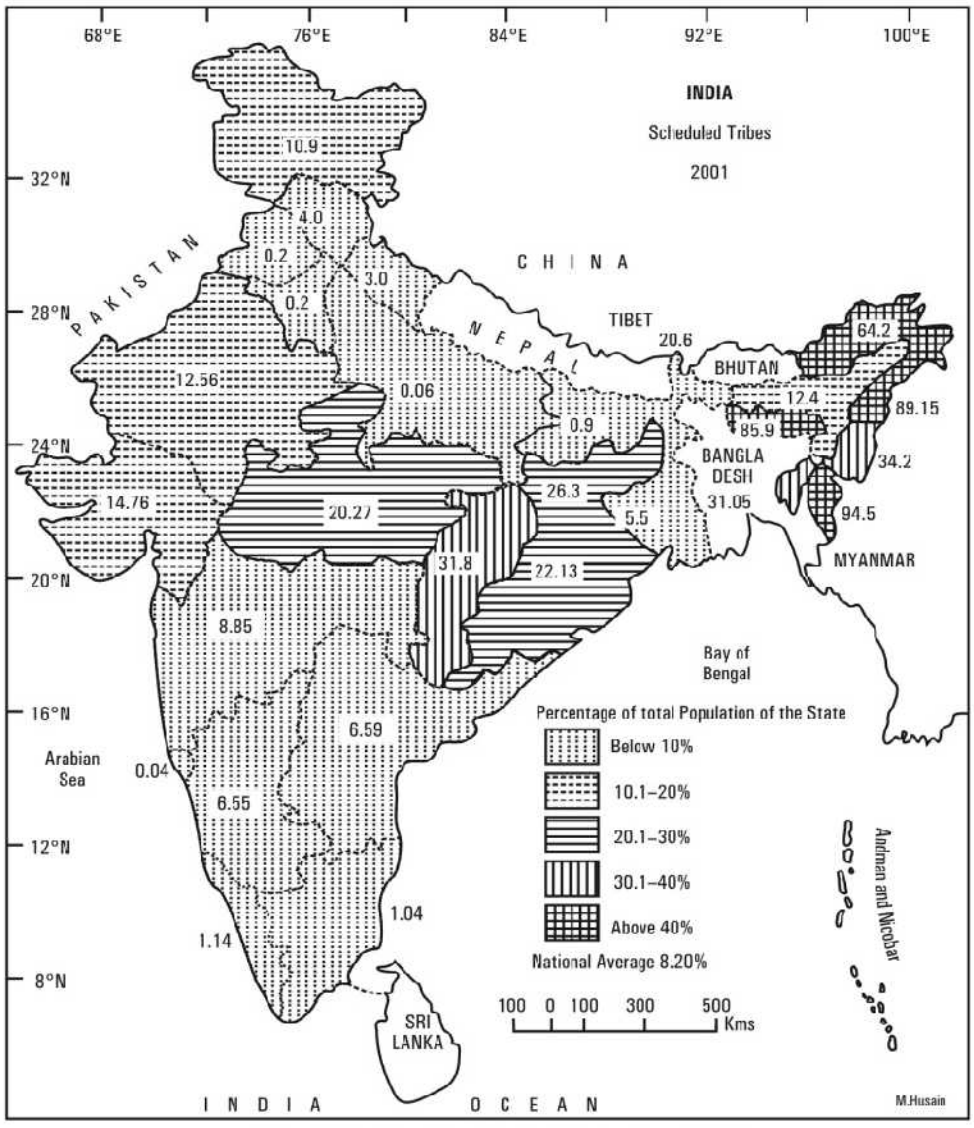

Fig. 11.7 – Density of scheduled tribes, 2001

Table 11.13: *Regional Distribution of Tribal Population*

1. North Eastern Region	Arunachal Pradesh, Assam, Manipur, Meghalaya, Mizoram, Nagaland, Tripura and Sikkim **(Fig. 11.8)**.
2. Central Tribal Belt (CTB)	Andhra Pradesh, Bihar, Chhattisgarh, Dadra and Nagar Haveli, Daman and Diu, Gujarat, Jharkhand, Madhya Pradesh, Maharashtra, Odisha, Rajasthan, and West Bengal.
3. Other States/Union Territories	Andaman and Nicobar Islands, Himachal Pradesh, Jammu and Kashmir, Karnataka, Kerala, Lakshadweep, Uttar Pradesh, Uttarakhand,

Source: Census of India, 2001.

The Sixth Schedule–Tribal Areas

The Sixth Schedule under Article 244 of the Constitution identifies autonomous districts in the tribal areas in the states of Assam, Meghalaya, Mizoram and Tripura. The state-wise details of scheduled tribal areas are as under:

Table 11.14: *India–Sixth Schedule – Tribal Areas*

Part I	Assam	1.	The North Cachar Hill District
		2.	The Karbi-Anglong District
		3.	The Bodo Land Territorial Area District
Part II	Meghalaya	1.	Khasi Hills District
		2.	Jaintia Hills District
		3.	The Garo Hills District
Part IIA	Tripura		Tripura Tribal Area District
Part III	Mizoram	1.	The Chakma District
		2.	The Mara District
		3.	The Lai District.

Source: India 2009, pp.969-70.

The administration of the autonomous districts and autonomous regions is done through District Councils/Regional Councils.

Scheduled Castes

The term *scheduled castes* appeared for the first time in the Government of India Act, 1935 and the Government of India Castes Order, 1936. Dr. B.R. Ambedkar preferred to call them the '*Depressed Classes*', while Mahatma Gandhi called them the '*Harijans*'. The Constitution of India retained the term scheduled castes.

The origin of the Scheduled Castes lies in the ancient past when the various Hindu scriptures placed them at the lowest ladder of Chaturvarna (four-fold hierarchial social order). Perhaps it was based on division of labour initially, but became hereditary and exclusive practice of the dogmatic doctrine of purity and pollution. The main scheduled castes of different states have been given in **Fig. 11.9**.

Scheduled castes are found in almost all the states of India with varying proportion and percentages. The percentages of schedules

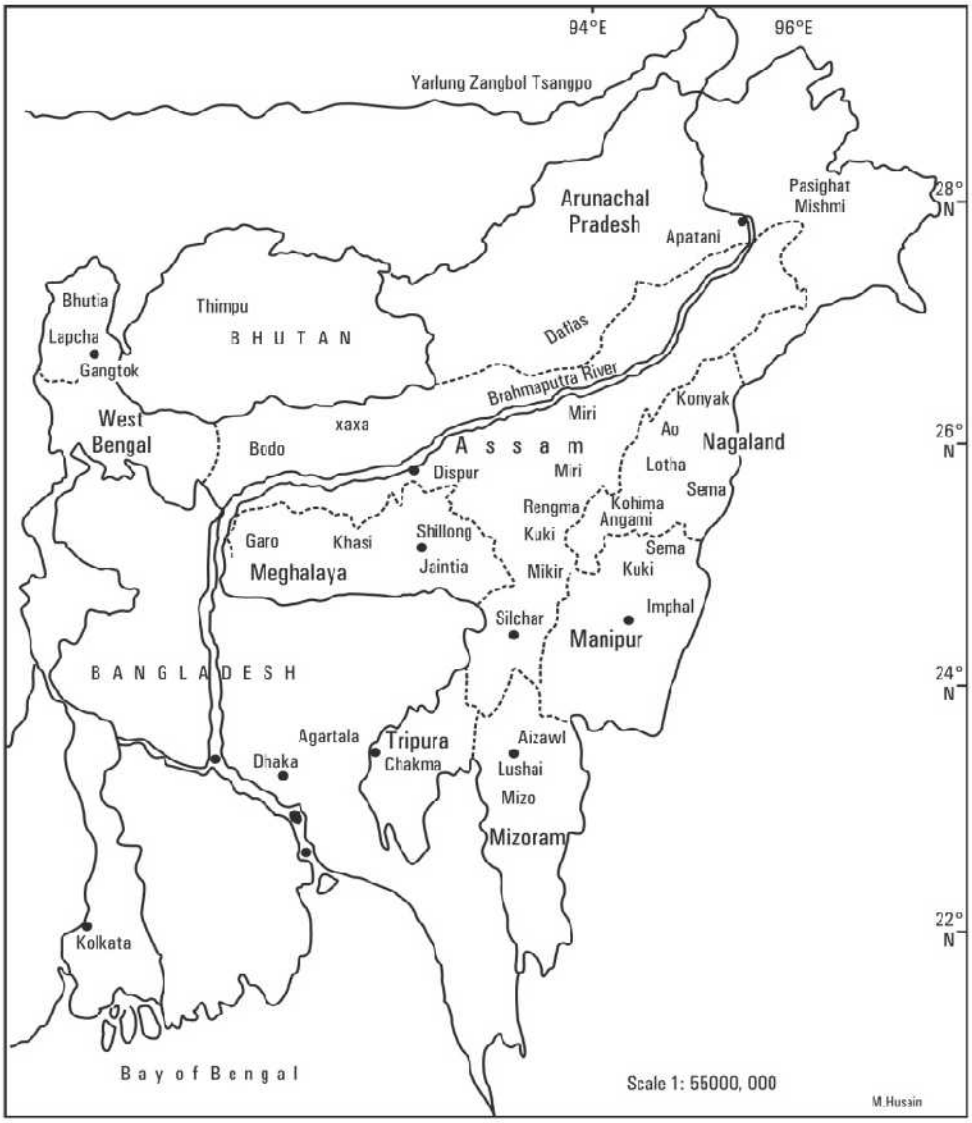

Fig. 11.8 – North-East India – Major tribes

castes population in different states have been shown in **Fig. 11.10,** while their absolute number and percentage share in population has been given in **Table 11.11.** It may be observed from **Fig. 11.10** that the highest percentage of scheduled castes is found in Punjab (28.85%), followed by Uttar Pradesh (21.95 %), Haryana (19.35%) and Uttarakhand (17.87 %). The states of north east India have, however, an insignifant proportion of the scheduled tribes.

Indian Minorities: Muslims, Christians, Sikhs, Buddhists, and Zoroastrians (Parsis) have been notified as minorities as per the provision under the *National Commission for Minorities (NCM) Act, 1992.* These five communities

about 18.74 per cent of the country's population. Government of India has taken the following measures for the welfare of minorities:

Constitutional Measures

(i) National Commission for Minorities: The Minorities Commission which was set up in January 1978 by a resolution issued by the Ministry of Home Affairs became a statutory body with the enactment of the National Commission for Minorities Act, 1992. The Commission is based on seven members (including a Chairperson and a Vice-Chairperson). The Act stipulates that 5 members including the Chairperson shall be from amongst the minority community.

(ii) National Commission for Religious and Linguistic Minorities: (a) This Commission suggests criteria for identification of socially and economically backward sections among religious and linguistic minorities. (b) The Commission recommends measures for welfare of the socially and economically backward section among the religious and linguistic minorities. (c) It suggests the necessary constitutional, legal and economic and administrative modalities as required for the implementation of their recommendations.

(iii) The Central Wakf Council: The *Wakf* is a permanent dedication of moveable and immovable properties for the purposes recognised by the Muslim Personal Law as religious, pious, or charitable. Apart from the religious aspects, the Wakfs are also instruments of social and economic upliftment. The *Wakf Boards* come under the Ministry of Social Justice and Empowerment. For the proper functioning of the boards, the Central Wakf Council was established as a statutory body by the Central Government in 1964. The Union Minister in charge of Wakf is the Chairperson of the Central Wakf Council. It is playing an important role by way of implementing the following schemes:

(i) Development of the Urban Wakf Properties.

(ii) Educational Development Programme.

(iv) Special Officer for Linguistic: The officer, commonly known as the Commissioner for Linguistic Minorities was created in 1957. The Commissioner for Linguistic Minorities has his headquarters at Allahabad with Regional Offices at Kolkata, Belgaum and Chennai. It safeguards the interest of the linguistic minorities.

(v) Economic Development:

National Minorities Development and Finance Corporation: It provides concessional financing for self employment activities to eligible persons belonging to minorities having family income below the poverty line. The authorised capital for this purpose is Rs. 650 crores.

(vi) Educational Development

Maulana Azad Education Foundation: This is a registered society with the objective of promoting education amongst the educationally backward sections of the society, and Muslim minorities in particular. The Government has contributed 100 crores to this society in the plan to promote education of the educationally backward peoples of minorities.

Ministry of Minority Affairs

The Ministry of Minority Affairs was created on 29th January, 2006 to ensure a focused approach to the issues relating to the minorities and to play a pivotal role in the overall policy planning co-ordination evaluation and review of the regulatory and development programme for the benefit of the minority communities.

Prime Minister's New 15-Point Programme for the Welfare of Minorities

The Prime Minister's 15-Point Programme for the Welfare of Minorities was announced in June, 2006. The objectives of the programme are:

(a) Enhancing opportunities for education.

(b) Ensuring an equitable share for minorities in economic activities and employment, through existing schemes, enhanced credit support for self employment and recruitment to state and central government jobs.

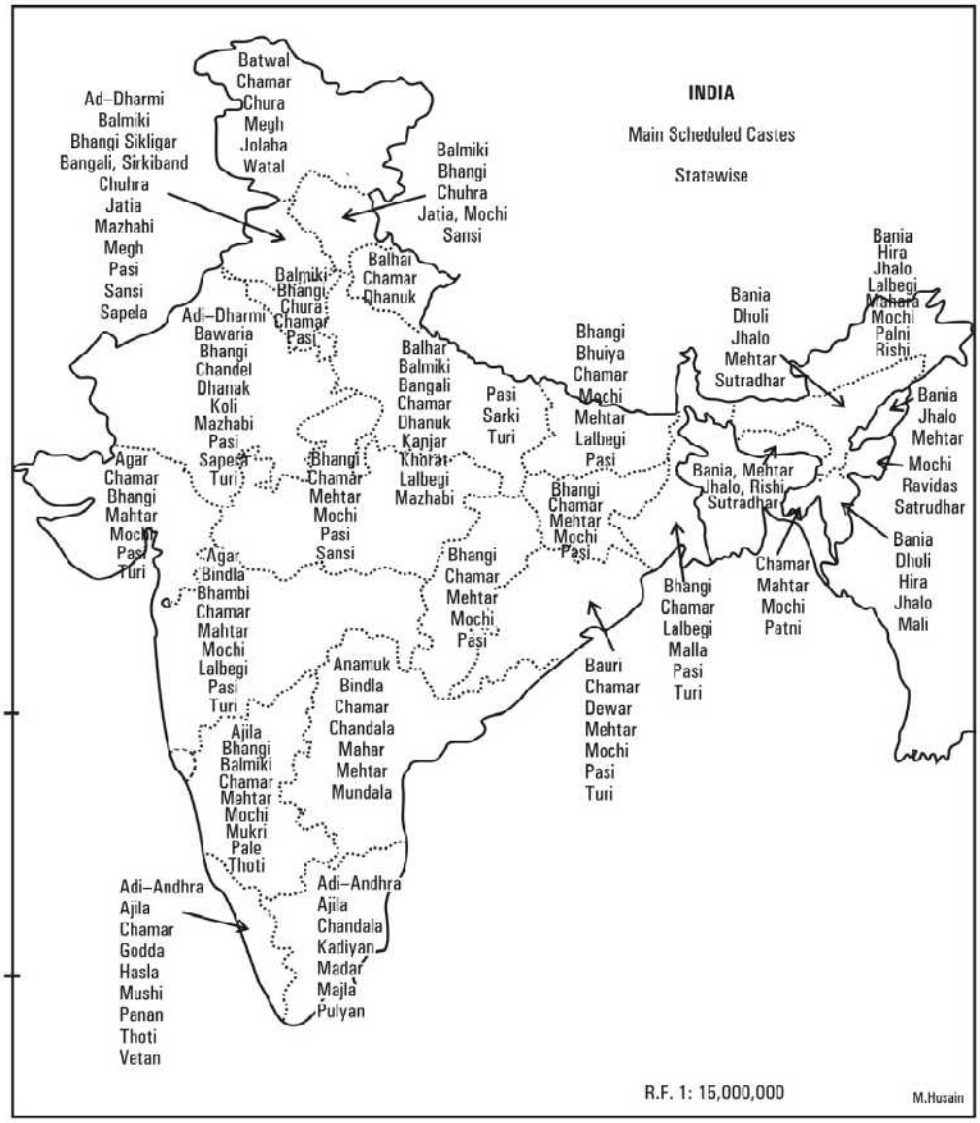

Fig. 11.9 – Main scheduled castes of India

recruitment to state and central government jobs.

(c) Improving the conditions of living of minorities by ensuring an appropriate share for them in infrastructure development schemes.

(d) Prevention and control of communal disharmony and violence.

(e) To ensure that the benefits of various government schemes for the under-privileged reach the disadvantaged section of the minority communities.

(f) It also provides that, wherever possible, 15% of physical targets and financial outlays under various schemes should be marked for minorities.

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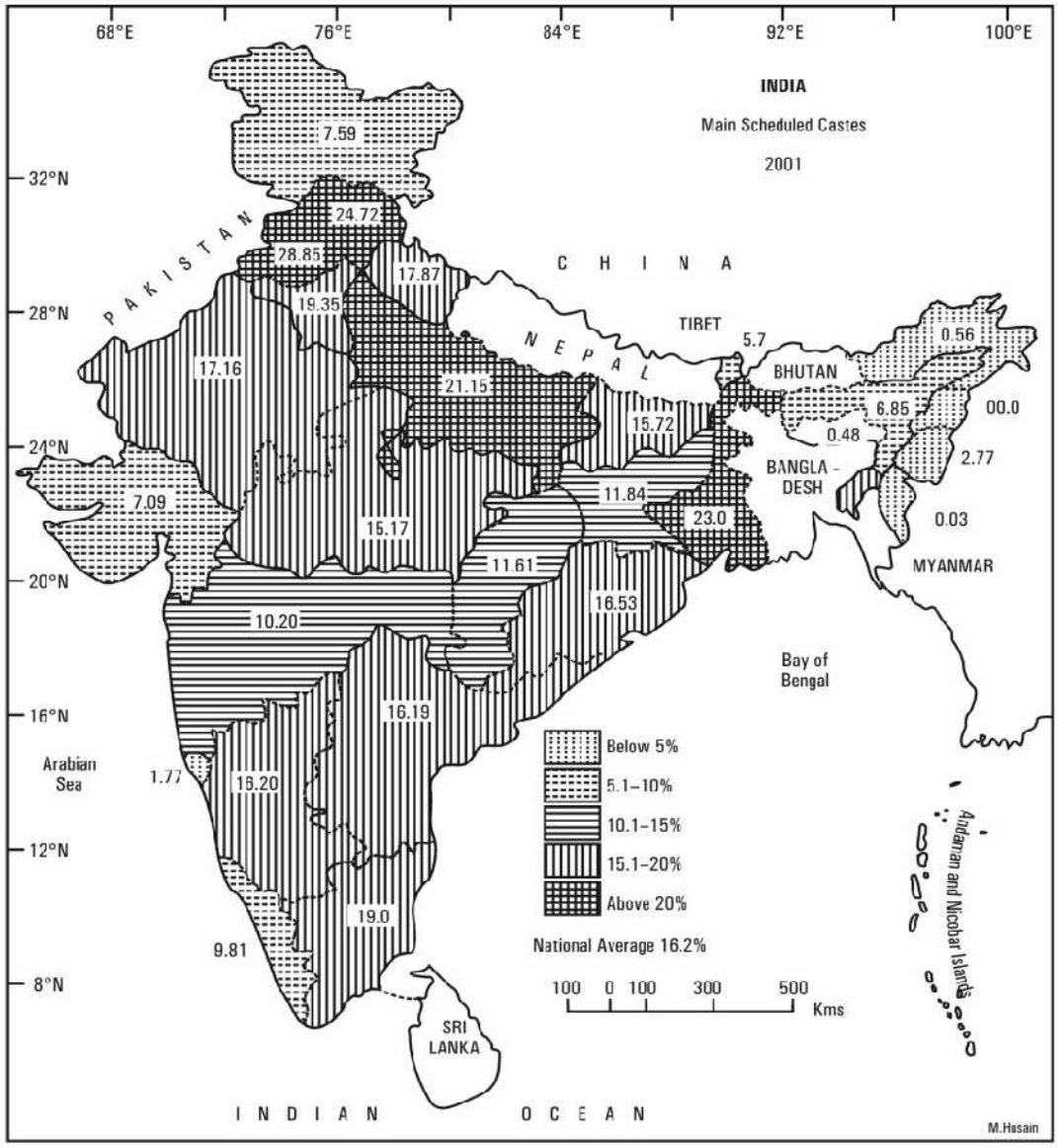

Fig. 11.10 – Density of Scheduled Caste Population, 2001

Some of the other schemes launched for the minority communities are as under:

(i) Merit-cum-Means Scholarship

This scheme is fully funded by the Central Government. Every year 20,000 new scholarships are to be provided for technical and professional courses at under-graduate and post-graduate levels. The amount of scholarship is Rs. 20,000 per annum.

Post-Matric Scholarships

This is a scheme fully funded by the Central Government. The scholarship is awarded to the

Pre-Matric Scholarship

This is being implemented on a sharing basis between the Centre and the States in the ratio of 75:25 for students in class I to class X. Fees up to Rs. 4,700 per annum will be reimbursed to the students under this scheme.

Identification of Minority Concentration Districts

Ninetyminority concentration districts (MCD) have been identified, based on the population data of 2001 Census and relevant backwardness issued parameters.

A Coaching and Allied Scheme

This scheme was launched in July 2007 with a view to improve the representation of minorities in government service and public sector undertakings, and also to cater to the emerging trends of the job market.

Human Resources

Humans are the ultimate source of a nation. Human resource means human capital. A country should introduce manpower planning for the development of human resources.

Human resources must be considered both from the angle of assets as well as liabilities. For achieving economic development, proper utilization of both natural as well as human resources is essential. A judicious utilization of natural resources largely depends on the extent of human resources. But too much population will again eat up all the fruits of development.

The term human capital formation implies the development of abilities and skills among the population of the country. In order to develop human resource, a country should introduce manpower planning for the development of its human resources.

Significance of Human Resource Development

Following are the merits of human resource development:

1. **Proper Utilisation of Natural Resources:** Qualitative and quantitative development of human resources are very much required for the proper utilization of natural resources.
2. **Increased Productivity:** It has been said by the leading social scientists like Prof. Galbraith that 'we now get the larger part of industrial growth not from capital investment but from investment in men and improvements brought about by improved men'.
3. **Development of Skills:** Slow growth in underdeveloped countries is mostly resulted from lack of investment in human capital.
4. **Increased Volume Output:** The production increases as the knowledgeable and skilled workers can make a judicious use of all resources at their disposal.
5. **Raises Per Capita Income:** Human resource development can raise per capita income of the country through increased formation of human capital.
6. **Addition to Productive Capacity:** Human resource development in the form of human capital formation can make necessary addition to the productive capacity of a country.
7. **Tool for Economic Change:** Human resource development can make the people knowledgeable, skilled and physically fit. This can also change the attitude of the people and improve the personal qualities of people.
8. **Improving Quality of Life:** Human resources development can pace the way for improving quality of the life of the people in general.

Human Development

According to the Human Development Report 2013, India ranks 136 out of the 170 countries. The human development index of India at state level has been plotted in **Fig. 11.11**. It may be

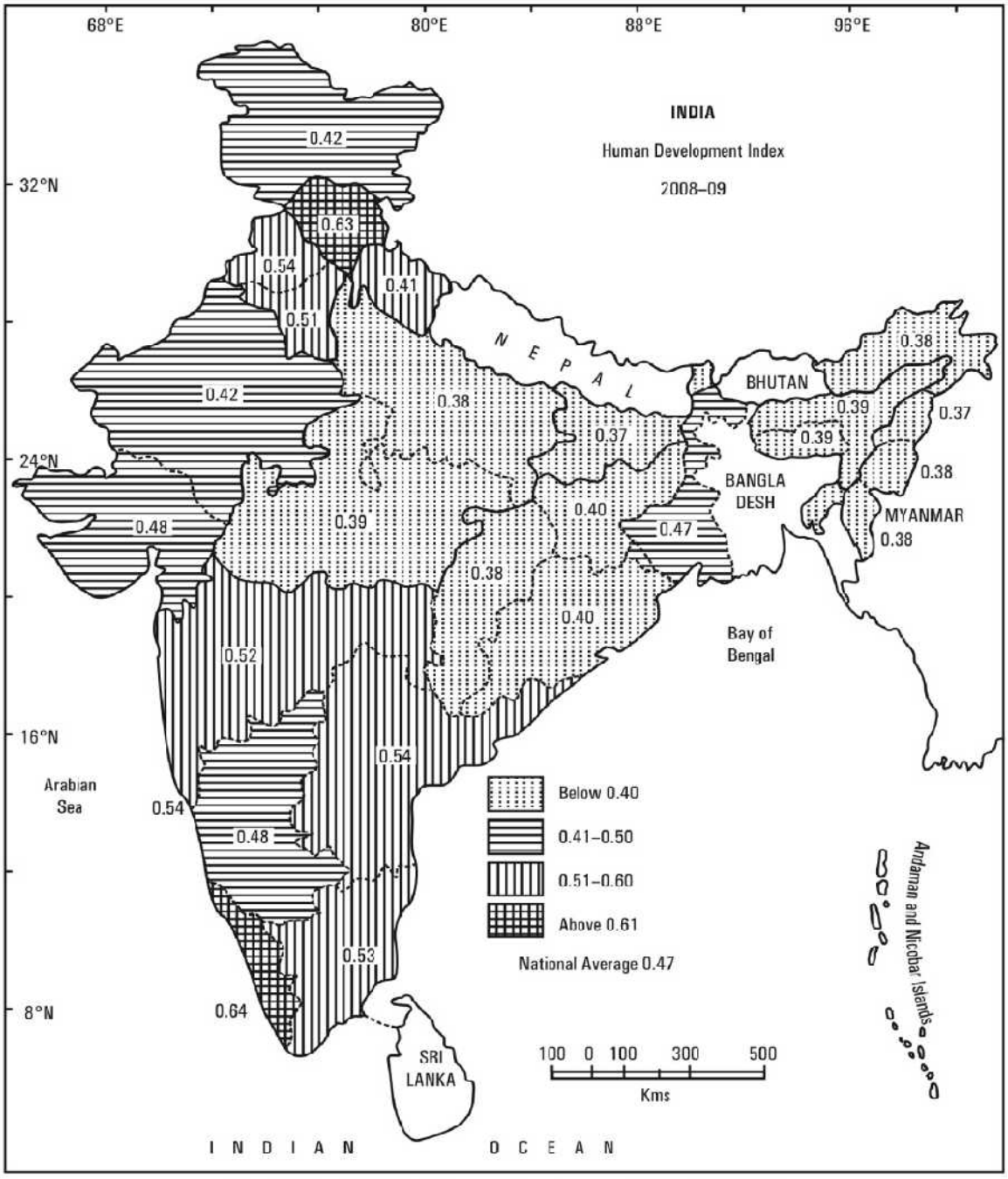

Fig. 11.11 – INDIA – Human Development Index 2008–09.

Poverty in India

According to the official figures, about one-third of the total population of India is below the poverty line. The incidence of poverty in different states has been shown in **Fig. 11.12.** It may be seen from this figure that Odisha has the highest percentage of poverty being 46.4 per cent followed by Bihar 41.4 per cent and Jharkhand 40.3 per cent. The state of Punjab has the lowest percentage of poverty (8.4%) followed by Haryana (14%) and Kerala 15%.

***Table 11.16:** Poverty in India, 2007-08*

	State/Union Territory Poverty Line	*Percentage of Population below*	*State/Union Territory Poverty Line*	*Percentage of Population below*
1.	Odisha	46.40	18. Rajasthan	22.10
2.	Bihar	41.40	19. Tamil Nadu	22.5
3.	Chhattisgarh	40.90	20. Meghalaya	22.00
4.	Jharkhand	40.30	21. Gujarat	16.80
5.	Assam	39.70	22. Mizoram	16.00
6.	Madhya Pradesh	38.30	23. Kerala	15.00
7.	Arunachal Pradesh	35.00	24. Haryana	14.00
8.	Tripura	33.0	25. Himachal Pradesh	10.00
9.	Uttar Praesh	32.8	26. Jammu & Kashmir	9.00
10.	Sikkim	32.00	27. Punjab	8.40
11.	Nagaland	32.00	28. Goa	8.40
12.	Uttarakhand	31.00	**Union Territories**	
13.	Maharashtra	30.70	1. Andaman & Nicobar Islands	21.99
14.	Andhra Pradesh	25.80	2. Silvassa	15.90
15.	Karnataka	25.00	3. Lakshadweep	15.00
16.	West Bengal	24.7	4. Daman & Diu	14.00
17.	Manipur	23.00	5. Delhi	10.00
			6. Puducherry	10.00
			7. Chandigarh	5.70

Source: Planning Commsission of India, 2001: India–National Human Develoment Report, p.166.

The National Population Policy of India, 2000

The rapid growth of Indian population has created numerous socio-economic and ecological problems. In order to reduce the growth of population, the government of India designed a population policy in 2000. The salient points of the population policy are given below:

1. Address the unmet needs for basic reproductive and childcare services, supplies and infrastructure.
2. Make school education compulsory up to the age 14 years, and reduce the dropouts at secondary school levels to below 20 per cent for both boys and girls.
3. Reduce infant mortality to below 30 per thousand of population.

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4. Reduce maternal mortality to below 100 per 1000 of population.
5. Achieve universal immunisation of children against all vaccine-preventable diseases.
6. Promote delayed marriage for girls, not earlier than 18 years and preferably after 20 years of age.
7. Achieve 80 per cent institutional deliveries and 100 per cent deliveries by trained persons.
8. Achieve universal access to information/ counselling and services fertility regulation.
9. Achieve 100 per cent registration of births, deaths, marriages, and pregnancies.
10. Contain the spread of AIDS and promote greater integration between the management of productive tract infections and sexually transmitted diseases.
11. Prevent and control preventable diseases.
12. Integrate Indian System of Medicine (ISM) in the provision of reproductive and child health services and reaching out to all households.
13. Promote vigorously the Small Family Norm to achieve replacement level of Total Fertility Rate.
14. Bring out convergence in implementation of social sector programmes so that family welfare becomes a people-centred programme.

Strategies

To achieve the above national socio-demographic goals, the policy document has outlined the following strategies:

(i) Decentralised planning and programme implementation.
(ii) Convergence of service delivery at village level.
(iii) Empowering women for improved health and nutrition.
(iv) Childcare services.
(v) Meeting the urgent needs for family welfare services.
(vi) Operational strategies for urban slum dwellers, tribal communities, hill area population, and displaced and migrant population; increased participation of men in planned parenthood.
(vii) Diverse healthcare providers.
(viii) Collaboration with the NGOs and private sector.
(ix) Contraceptive technology and research in reproductive and child health.
(x) Information, education and communication.
(xi) The Government of India has appointed the National Commission on Population with the Prime Minister as the Chairman.

Table 11.17: *India–Classwise Number of Towns and Cities and their Population, 2001*

Class	*Population*	*Number*	*Population (in million)*	*% of Total Urban Development*	*% of Growth 1991-2001*
Total of all classes		5161	285.35	100.00	31.13
I	> 100,000	423	172.04	61.48	23.12
II	50,000-99,999	498	34.43	12.30	43.45
III	20,000-49,999	1386	41.97	15.00	46.19
IV	10,000-19,999	1560	22.60	8.08	32.94
V	5,000 9,999	1057	7.98	2.85	41.49
VI	< 5000	227	0.80	0.29	21.21

Source: Census of India, 2001.

(ii) Convergence of service delivery at village level.

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Source: Census of India, 2001

***Table 11.18:** India with Population of at least One Million/Urban Agglomerations, 2001*

Rank	*Name of Urban Agglomerations*	*Population in Million*
1.	Greater Mumbai	16.37
2.	Kolkata	13.22
3.	Delhi	12.79
4.	Chennai	6.42
5.	Bangaluru	5.69
6.	Hyderabad	5.53
7.	Ahmedabad	4.52
8.	Pune	3.76
9.	Surat	2.81
10.	Kanpur	2.69
11.	Jaipur	2.32
12.	Lucknow	2.27
13.	Nagpur	2.21
14.	Patna	1.71
15.	Indore	1.64

16.	Vadodara	1.49
17.	Bhopal	1.48
18.	Coimbatore	1.45
19.	Ludhiana	1.39
20.	Kochi	1.36
21.	Vishakhapatnam	1.33
22.	Agra	1.32
23.	Varanasi	1.21
24.	Madurai	1.19
25.	Meerut	1.17
26.	Nashik	1.15
27.	Jabalpur	1.12
28.	Jamshedpur	1.10
29.	Asansol	1.09
30.	Dhanbad	1.06
31.	Faridabad	1.05
32.	Allahabad	1.05
33.	Amritsar	1.01
34.	Vijaywada	1.01
35.	Rajkot	1.00
	Total	107.88

Source: Census of India, 2001

Urban Slums

A slum is an area of poor housing, often characterised by multi-occupance and overcrowding. Urban slums are the products urban explosion which has accompanied industrialisation. The main causes of urban slums are: (i) rapid growth of population, (ii) heavy pressure on agricultural land, (iii) unemployment, (iv) attraction of jobs in cities. The slums are characterised with poverty, malnutrition, disease, poor sanitation, ignorance, poor standard of living, crimes, and corruption. The statewise distribution of slum population in India has been shown in **Fig. 11.13**. The largest percentage of slum population is in Haryana (33%), followed by Andhra Pradesh (32.6%) and Maharashtra 31.65 per cent.

Naxalism in India

The Naxal affected areas of India have been shown in **Fig. 11.14**. It may be seen from this figure that the states of Andhra Pradesh, Chhattisgarh, Jharkhand, Odisha, Bihar and West Bengal are the worst affected regions of India. The regions Maharashtra, Gujarat, Karnataka, and parts of Kerala and Tamil Nadu are also infested with Naxalites.

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20.	Koch	1.36
21.	Vishakhapatnam	1.33
22.	Agra	1.32
23.	Varanasi	1.21
24.	Madurai	1.19
25.	Meerut	1.17
26.	Nashik	1.15
27.	Jabalpur	1.12
28.	Jamshedpur	1.10
29.	Asansol	1.09
30.	Dhanbad	1.06
31.	Faridabad	1.05
32.	Allahabad	1.05
33.	Amritsar	1.01
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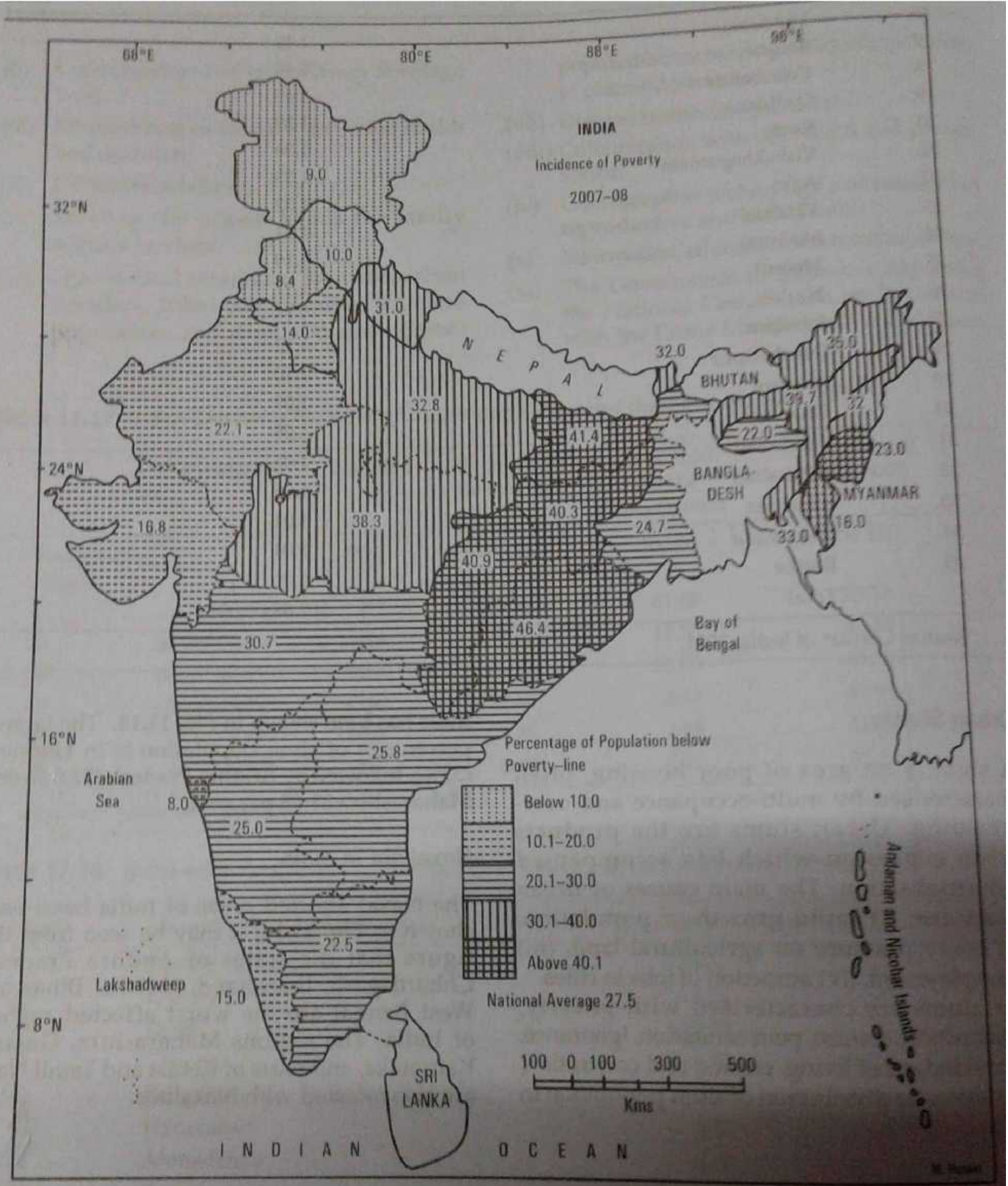

Fig. 11.12 – India: Incidence of poverty

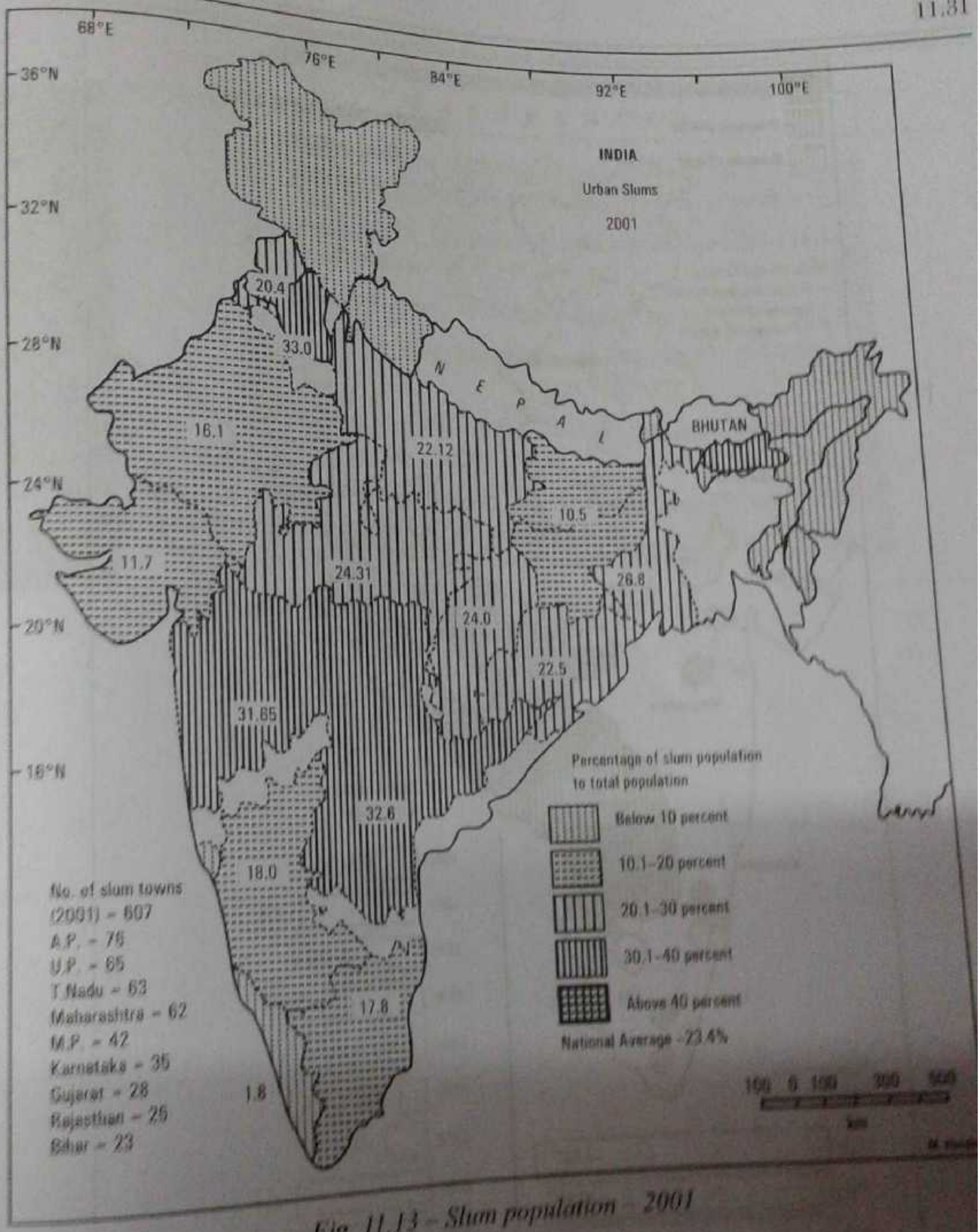

Fig. 11.13 – Slum population 2001

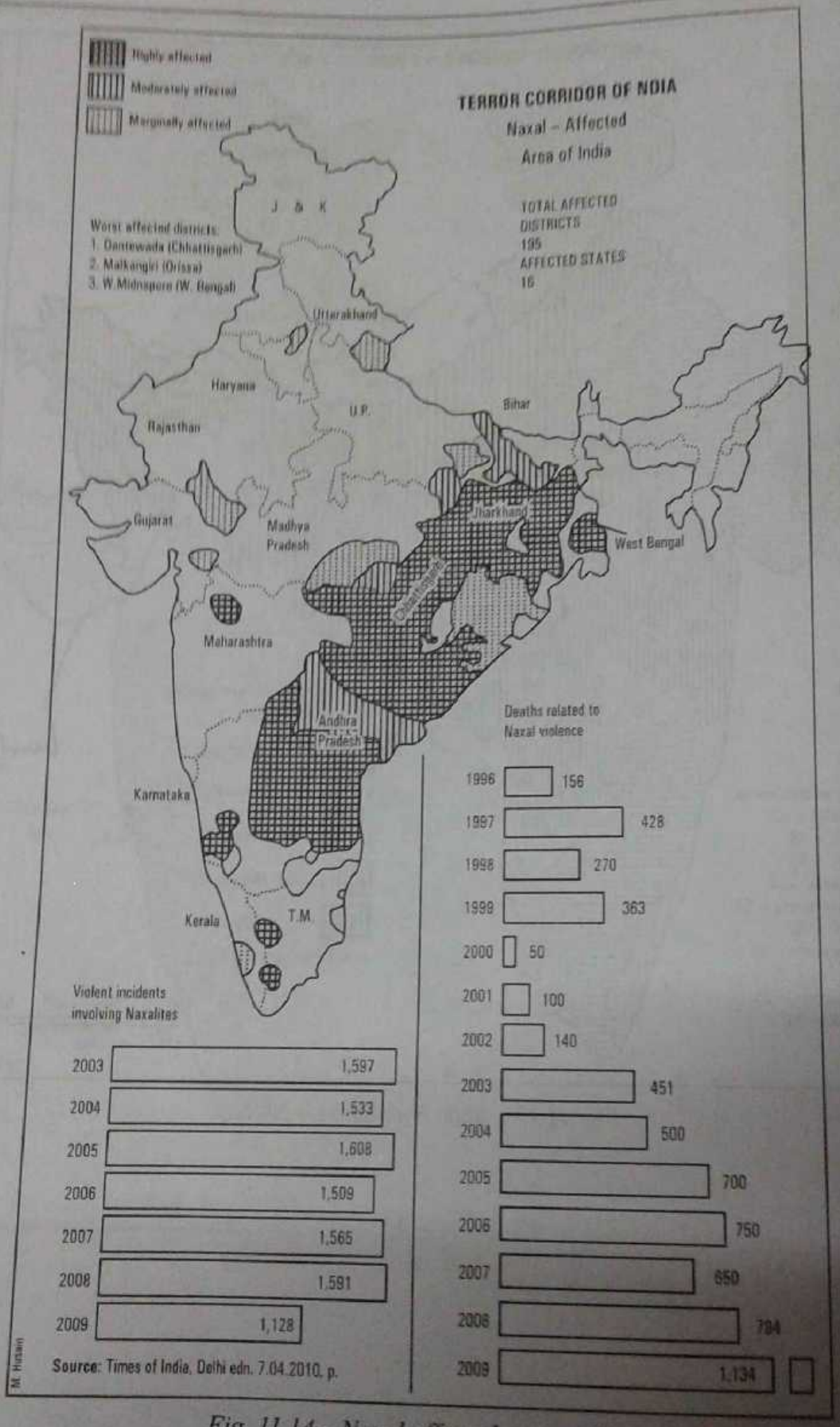

Fig. 11.14 – Naxal affected areas of India

Chapter Twelve

Indian States

Facts about Indian Population (Census – 2011)

- Total population: 1210. 19 million (17.5% of the World population)
- Density of population: 382 persons per sq km
- Sex-ratio: 940/1000
- Child sex-ratio: (0-6 years): 914/1000
- Literacy rate: 74 per cent
- Males literacy rate: 82 per cent
- Females literacy rate: 65 per cent
- Highest literacy rate: Karela 94%
- Lowest Literacy rate: Bihar 64%
- Most populous state: U.P 199 million
- Second most populous state: Maharashtra (112.4 million)
- Highest density of population : Bihar 1102 persons per sq km
- 2nd highest density of population: West Bengal 1029 persons per sq km
- Percentage growth in 2001-2011: 17.64%

1. Andhra Pradesh

Area: 2,75,069 sq km
Population: 84.7 million (2011)
Capital: Hyderabad
Languages: Telugu and Urdu

The state of Andhra Pradesh is bounded by Maharashtra, Chhattisgarh and Odisha in the north, Karnataka in the west and Tamil Nadu in the south, while the eastern boundary is formed by the Bay of Bengal **(Fig. 12.1)**.

Districts: 1. Adilabad, 2. Ananthapur, 3. Chittoor, 4. Cuddapah, 5. East Godavari, 6. Guntur, 7. Hyderabad, 8. Karimnagar, 9. Khammam, 10. Krishna, 11. Kurnool, 12. Mahboobnagar, 13. Medak, 14. Nalgonda, 15. Nellore, 16. Nizamabad, 17. Prakasam (Ongole), 18. Rangareddy, 19. Srikakulam, 20. Visakhapatnam, 21. Vizianagram, 22. Warangal, 23. West Godavari.

Agriculture: About 62 per cent of the total population of Andhra Pradesh is directly or indirectly dependent on agriculture. Rice is the major food crop and staple food of state. The main crops include rice, *jowar, bajra,* maize, *ragi,* small millets, pulses, castor, tobacco, cotton, sugarcane, fodder and vegetables. Forests cover 23% of state's area. Important forest products are teak, eucalyptus, casurina, bamboo and softwood. Andhra Pradesh occupies the first position in respect of agricultural loans from commercial and cooperative banks.

Irrigation Projects: Vamsadhara, Godavari Delta System, *Yeleru* Reservoir Project, Pennar Delta System, Pennar River Canal System, Tungbhadra Project, Nizamsagar Project, etc.The power projects include Nagarjunsagar, Srisailam, Upper Sileru, Lower Sileru, and Tungbhadra Hydel Projects. Ramagundam, Kothagudem, Vijaywada, Muddanur and Simhadri are the thermal power plants.

Minerals: Andhra Pradesh has the largest deposits of quality asbestos in the country. Other important minerals found in the state are copper, manganese, mica, coal, diamond, precious stones, and limestone. The Singareni coal mine is one of the largest coal deposits of the country.

Tourist Centres: Araku Valley, Bhadrachalam, Charminar, Golconda Fort in Hyderabad, Fort of Warangal, Horsley Hills, Nagarjunsagar, Salarjung, and Thousand Pillar Temple.

2. Arunachal Pradesh

Area: 83,743 sq km

Population: 10,97, 968 (2001)

Capital: Itanagar

Languages: Aka, Miji, Monpa, Sherdukpen

Arunachal Pradesh, became a full-fledged state on Feb.20, 1987. Till 1972, it was known as the North-East Frontier Agency (NEFA). It gained the Union Territory status on 20th January and renamed as Arunachal Pradesh.

The state of Arunachal Pradesh is bounded by Tibet (China) in the north, Myanmar in the east, Assam and Nagaland in the south and Bhutan in the west **(Fig. 12.2)**.

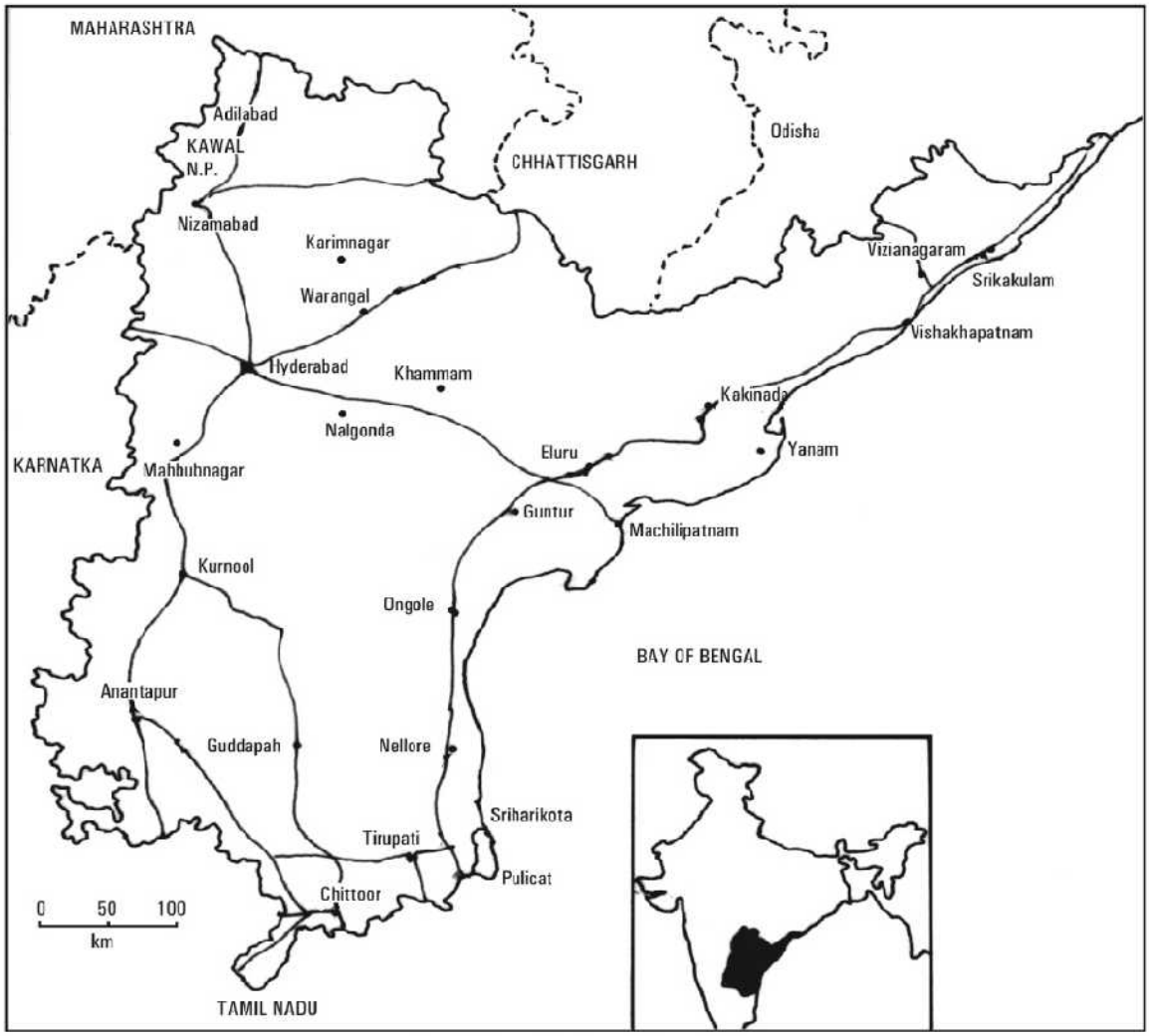

Fig. 12.1 – Andhra & Pradesh

Tourist Centres: Araku Valley, Bhadrachalam, Charminar, Golconda Fort in Hyderabad, Fort of Warangal, Horsley Hills, Nagarjunsagar, Salarjung, and Thousand Pillar Temple.

2. Arunachal Pradesh

Area: 83,743 sq km

Population: 10,97, 968 (2001)

Capital: Itanagar

Languages: Aka, Miji, Monpa, Sherdukpen

Arunachal Pradesh, became a full-fledged state on Feb.20, 1987. Till 1972, it was known as the North-East Frontier Agency (NEFA). It gained the Union Territory status on 20th January and renamed as Arunachal Pradesh.

The state of Arunachal Pradesh is bounded by Tibet (China) in the north, Myanmar in the east, Assam and Nagaland in the south and Bhutan in the west **(Fig. 12.2)**.

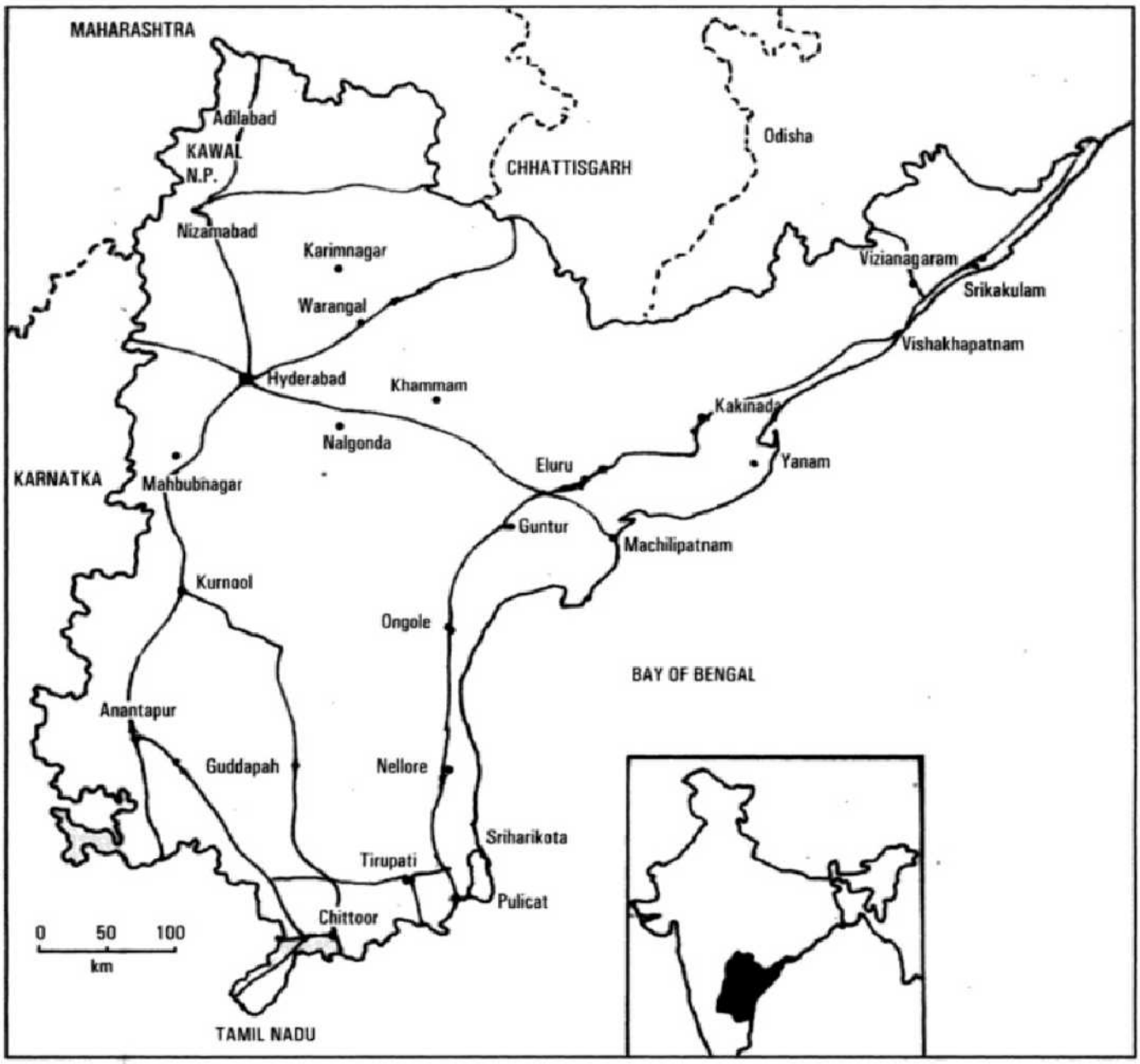

Fig. 12.1 – Andhra Pradesh

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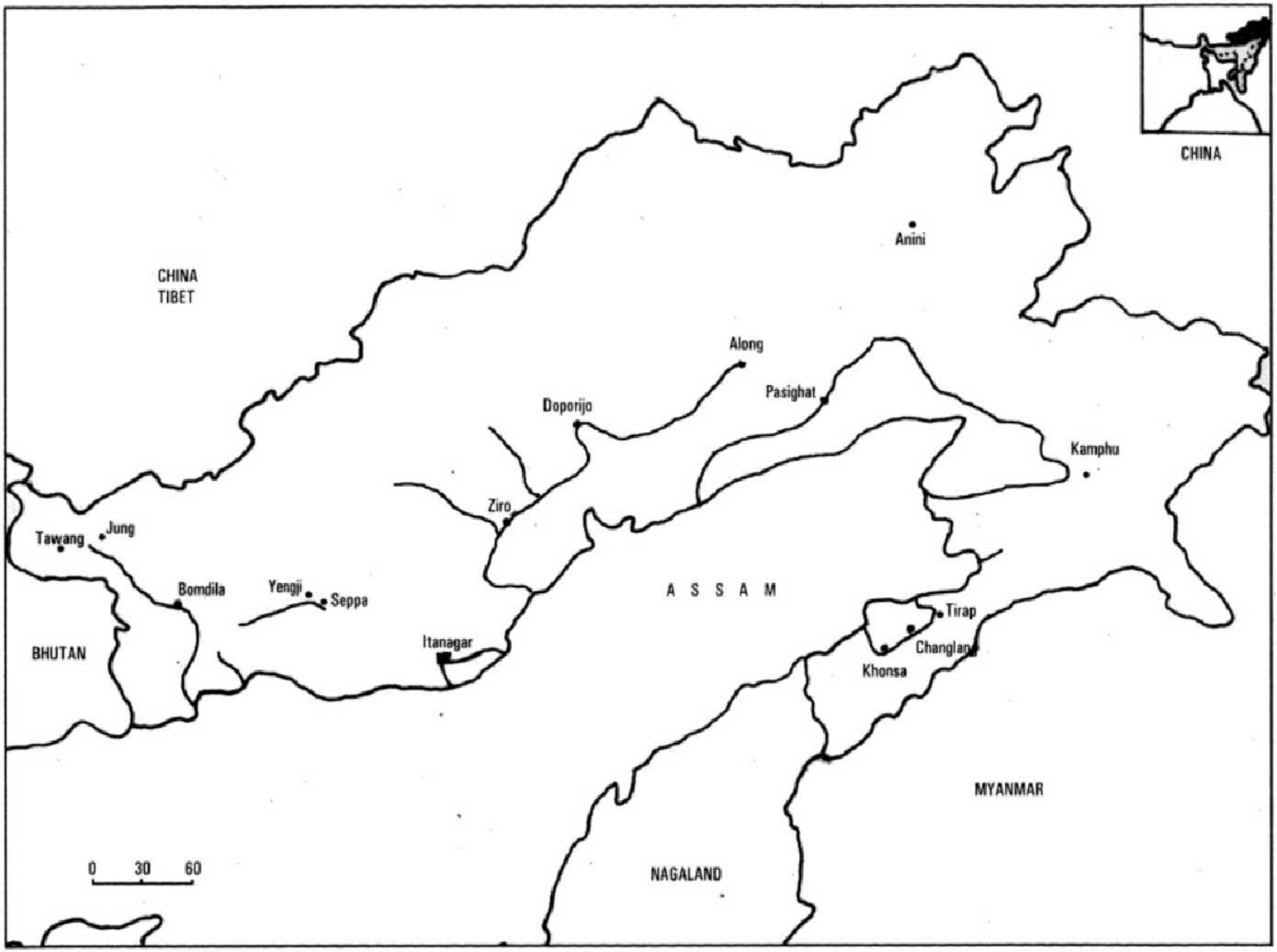

Fig. 12.2 – Arunachal Pradesh

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Districts: 1.Changlang, 2. Dibang Valley, 3. East Kamang, 4. East Siang, 5. Lohit, 6. Papum-Pare, 7. Lower Subansiri, 8. Tawang, 9. Tirap, 10. Upper Siang, 11. Upper Subansiri, 12. West Kamang, 13. West Siang.

Agriculture: Most of the people of the state are dependent on agriculture. In the hilly and mountainous areas Jhuming is main agricultural system. Ecouragement is being given to the cultivation of cash crops like apples, oranges, pineapple, potato, vegetables, and silviculture.

Minerals: The important minerals of Arunachal Pradesh include coal, limestone, and building materials.

Tourist Centres: The main places of tourist interest include Along, Bomdila, Daporijo-Namdapha, Dirand, Itanagar, Khonsa, Malinithan, Pasighat, Parushuram-Kund, Tapi, Tezu, and Twang.

3. Assam

Area: 78,438 sq km

Population: 2,66, 55, 528 (2001)

Capital: Dispur

Languages: Assamese and Bengali

The state of Assam is bounded by Bhutan and Arunachal Pradesh in the north, Arunachal Pradesh, Nagaland, and Manipur in the east, Mizoram and Tripura in the south, and West Bengal, Bangladesh, and Meghalaya in the south **(Fig. 12.3)**.

Districts: 1. Baksa, 2. Barpeta, 3. Bongaigaon, 4. Cachar, 5. Chirang, 6. Darrang,7. Dhemaji, 8. Dhubri, 9. Dibrugarh, 10. Goalpara, 11. Golagaht, 12. Hailkandi, 13. Jorhat, 14. Kamrup-Rural, 15. Karbi-Anglong, 16. Karimganj, 17. Kokrajhar, 18. Lakhimpur, 19. Morigaon, 20. Nagaon, 21. Nalbari, 22. North Cachar Hills, 23. Sibsagar, 24. Sonitpur, 25. Tinsukia, 26. Kamrup Metropolitan, 27. Udalguri.

Agriculture: Assam is essentially an agrarian state. The principal crops grown in the state are rice, jute, tea, cotton, oilseeds, sugarcane, fodder, vegetables and potato. In addition to these, oranges, banana, apple, pineapple, arecanut, coconut, guava, mango, jackfruit and citrus fruits.

Minerals: Crude-oil, natural gas, coal, limestone, refractory clay, etc.

Industries: Oil refineries, petrochemicals, fertilizers (Namrup), sugar, silk, paper, plywood, rice and oil-milling, polyester (Kamrup). Assam is well known for agro-based and forest-based industries. The main industries include oil-refineries, petrochemicals, and agricultural machinery. Cottage industries include handloom, sericulture, cane and bamboo articles, carpentry, brass and bell-metal crafts. Assam produces silk varieties of *Endi, Muga, Tassar*, etc. Muga silk is produced only in Assam in the world.

Tourist Centres: There are several national parks and wildlife sanctuaries in Assam, among which, the Kaziranga National Park and Manas Tiger Project (National Park) are internationally famous for the horned Rhino and Royal Bengal Tiger respectively. Haflong (health resort), Pobi-Tora and Orang, Majuli (the largest river island in the world), Chandubi lake, Hajo (meeting point of Buddhism, Hinduism and Islam) and Sualkuchi (famous for silk industry) are other tourist centres in the state.

4. Bihar

Area: 94,163 sq km

Population: 103.8 million (2011)

Capital: Patna

Language: Hindi, Urdu

The state of Bihar is bounded by Nepal in the north, West Bengal in the east, Jharkhand in the south and Uttar Pradesh in the west **(Fig. 12.4)**.

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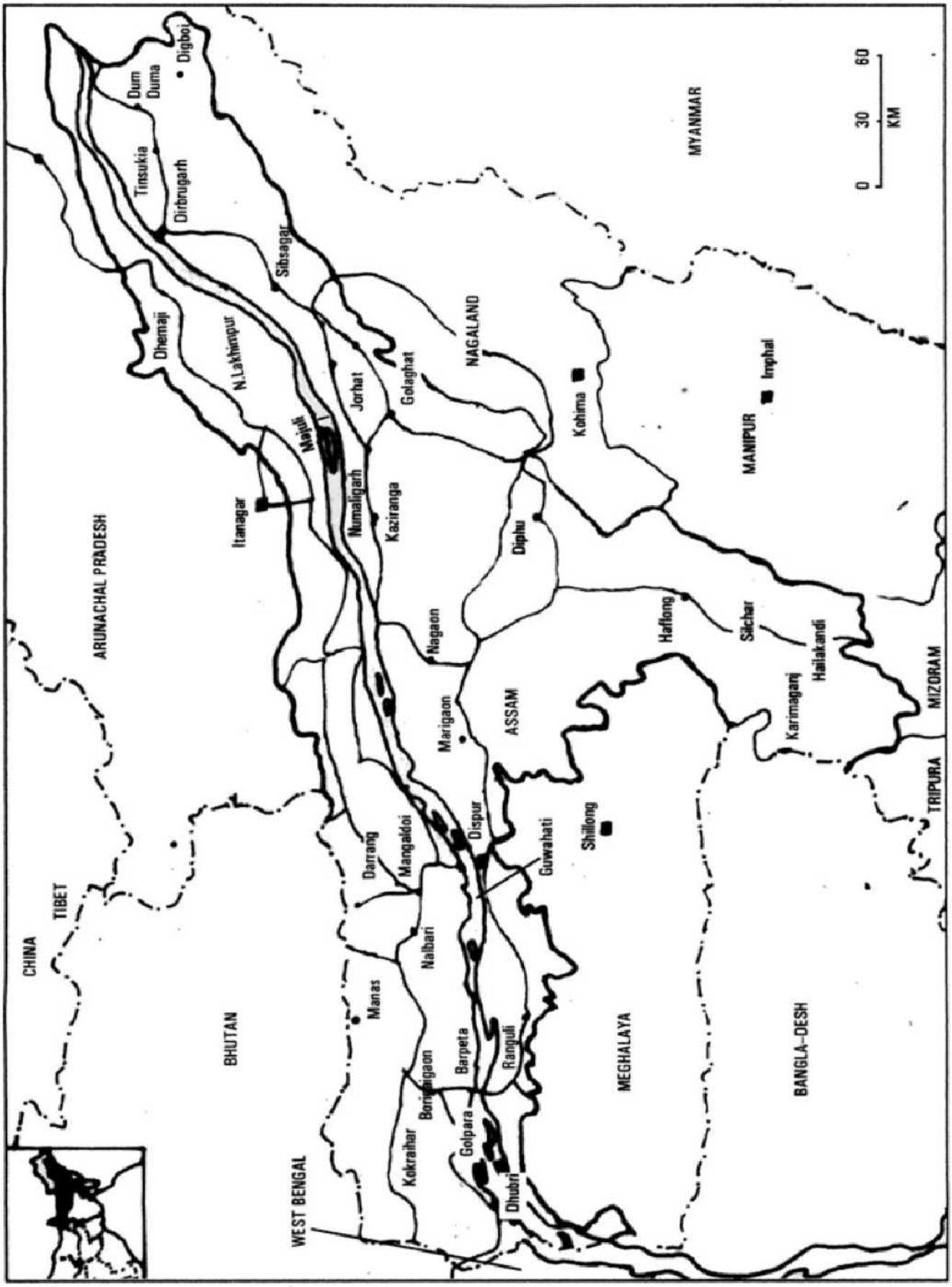

Fig. 12.3 – Assam

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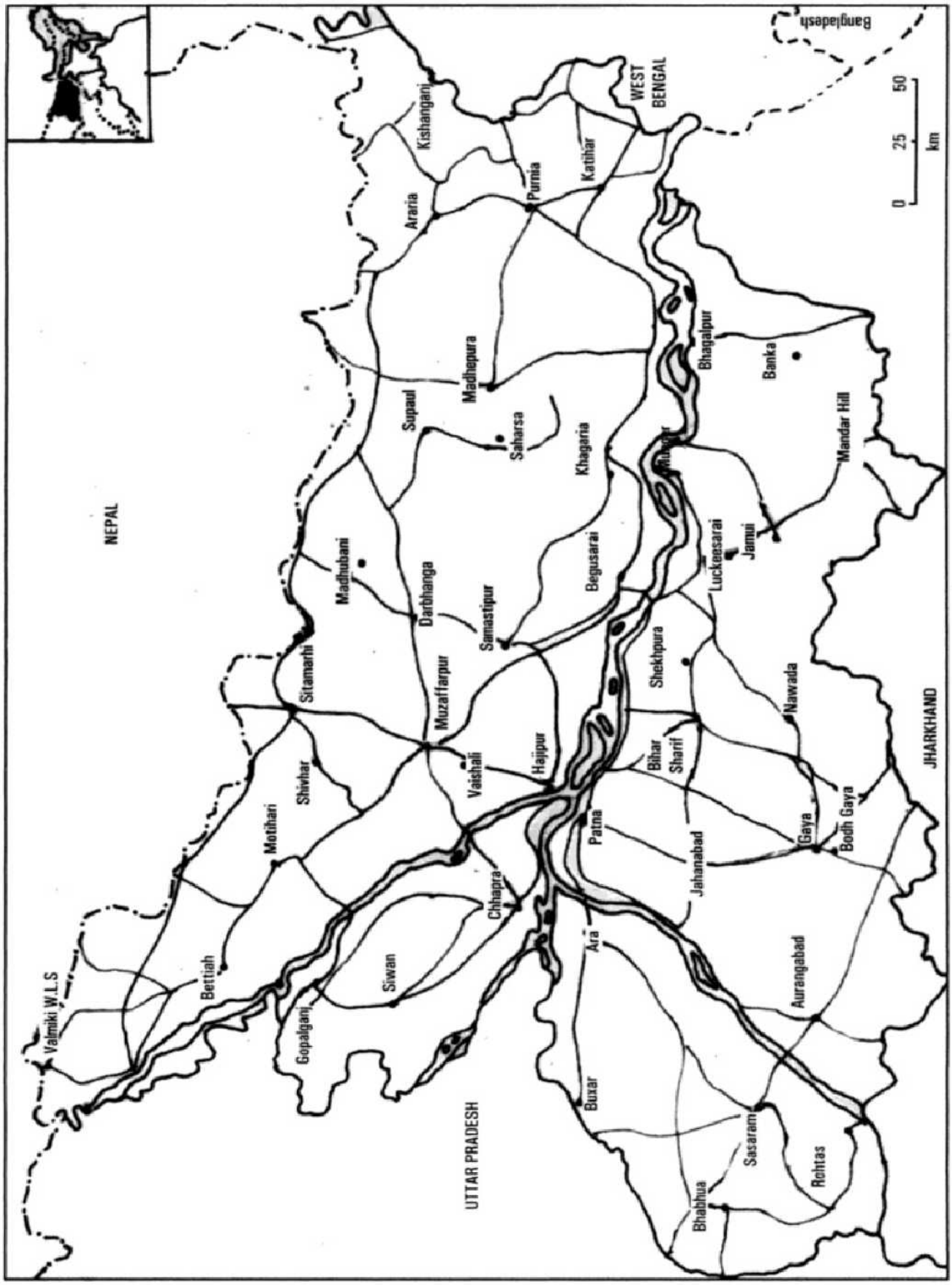

Fig. 12.4 – Bihar

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Districts: 1. Araria, 2. Arwal, 3. Aurangabad, 4. Banka, 5. Begusarai, 6. Bhabhua, 7. Bhagalpur, 8. Bhojpur, 9. Buxar, 10. Darbhanga, 11. Gaya, 12. Gopalganj, 13. Jahanabad, 14. Jamui, 15. Katihar, 16. Khagaria, 17. Kishanganj, 18. Koshi, 19. Luckeesarai, 20. Madhepura, 21. Madhubani, 22. Munger, 23. Muzaffarpur, 24. Nalanda, 25. Nawada, 26. Patna, 27. Paschami Champaran, 28. Purbi Champaran, 29. Purnea, 30. Rohtas, 31. Samastipur, 32. Saran, 33. Shekhpura, 34. Shivhar, 35. Sitamarhi, 36. Siwan, 37. Supaul, 38. Vaishali.

Rivers: The main rivers of Bihar are Ganga, Sone, Poonpoon, Phalgu, Dhadhar, Badua, Gandak, Bagmati, Kosi, and Gandak.

Agriculture: Over 70 per cent of the total population of Bihar is dependent on agriculture. Its main crops include rice, wheat, maize, pulses, sugarcane, potato, tobacco, oilseeds, onion, chillies, jute and mesta.

Industries: Major industries include Railway Wagon Plants of Bharat Wagon Ltd. Muzaffarpur, and Mokamah, Oil refineries and fertilizer at Barauni, pyrites-phosphates at Amjhor, cotton mills at Siwan, Pandaul, Bhagalpur, Mokamah and Gaya. Distilleries at Gopalganj, Champaran, Bhagalpur and Riga (Sitamarhi District), leather goods at Champaran, Muzaffarpur, and Barauni, jute mills at Katihar, and Samastipur, medicine plants at Muzaffarpur, Hajipur, etc.

Tourist Centres: In Bihar, the important places of tourist interest are Rajgir, Nalanda, Vaishali, Pawapuri (where Lord Mahavira breathed last and attained Nirvan), Bodh- Gaya, Vikramshila (ruins of Buddhist University of higher learning) Gaya, Patna (ancient of Pataliputra), Sasaram (Tomb of Sher-Shah Suri) and Madhubani (known for Madhubani Paintings), and Barabar Hills (Jehanabad).

5. Chhattisgarh

Area: 1,36,034 sq km

Population: 2,08,95,956 (2001)

Capital: Raipur

Language: Hindi

The state of Chhattisgarh was carved out of Madhya Pradesh as the 26th state of India on Ist November, 2000. It is bounded by Madhya Pradesh, Uttar Pradesh and Jharkhand in the north, Jharkhand and Odisha in the east, Andhra Pradesh in the south and Madhya Pradesh and Maharashtra in the west **(Fig. 12.5)**. Areawise Chhattisgarh is the ninth largest state and populationwise it is the seventeenth largest state of the country.

Districts: 1. Bastar, 2. Bijapur, 3. Bilaspur, 4. Dantewara, 5. Dhamtari, 6. Durg, 7. Janjgir-Champa, 8. Jashpur, 9. Kanker, 10. Kawardha, 11. Korba, 12. Koria,13. Raigar, 14. Raipur, 15. Rajnandgaon, 16. Mahasamand, 17. Naraynpur, 18. Sarguja.

Agriculture: Agriculture and allied activities account for nearly 80 per cent of the work force in the state. Its only 35 per cent of the geographical area is under cultivation. Rice, maize, wheat, oilseeds, groundnut, pulses and vegetables are the main crops. Horticulture is becoming increasingly important.

Irrigation: When the state came into being, the total irrigation capacity was 13.28 lakh hectares which has now increased to about 17 lakh hectares. The major projects completed are Tandula, Kodar and Pairy.

Minerals: Chhattisgarh is rich in coal, iron-ore, limestone, bauxite, dolomite, tin ore, gold, graphite, corundum, and diamonds. There are small deposits of gold, graphite, and corundum. It is the only tin producing state in the country.

Industries: Chhattisgarh produces about 15 per cent of the steel made in the country. Apart from Bhilai, there are 53 steel projects (sponge iron/ pig-iron route) in private sector in different stages of implementation. In addition to these, the state also has 11 ferro-alloy units, steel/cast-iron, engineering and fabrication units. Moreover, there are agro-based and food processing, chemical, plastic, construction material, forest produce based units.

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Tourist Centres: Situated in the heart of India, Chhattisgarh is endowed with a rich cultural heritage and attractive natural diversity. The state is full of ancient monuments, rare wild species, carved temples, Buddhist sites, Keshkal Valley, Kailash Caves, water falls, rock-paintings and attractive hills and plateaus. The important waterfalls include Chitrakote-Falls (30 m), and Tirathgarh-Falls (32 m) on Indravati and Kanger River respectively. Pali and Kendai waterfall in Korba District are also great attractions for tourists.

6. Goa

Area: 3,702 sq km

Population: 13,47,668 (2001)

Capital: Panaji

Languages: Konkani, Marathi, Gujarati.

The state of Goa is bounded by Maharashtra and Karnataka in the north, Karnataka in the south and east, while to the west lies the Arabian Sea **(Fig. 12.6)**.

District: 1. North Goa (Panaji), 2. South Goa (Margao).

Agriculture: Rice is the main crop. Pulses, *ragi*, and oil-seeds are also grown. Main cash crops are coconut, cashewnut, arecanut, sugarcane and fruits (pineapple, mango and banana).

Irrigation and Power: With the commissioning of dams like Selaulim, and Anjunem and other minor irrigation projects, the area of irrigation is increasing steadily.

Minerals and Industries: The state has 7110 small scale industrial units and 20 industrial estates. Mineral products are ferro-manganese, bauxite, and iron-ore contributing substantially to the economy of the state through exports.

Tourist Centres: The important tourist centres of Goa include Anjuna, Baga, Colva, Calangute, Harmal, Miramar, Vagator beaches. Dudhsagar, and Harvalem waterfalls (Mandovi River), and *Mayem lake* resorts are the other important places of tourist interests. The state has rich wild-life sanctuaries, viz. Bondla, Cotigao, Molem, and Dr. Salim Ali Bird Sanctuary at Chorao.

7. Gujarat

Area: 1,96,024 sq km

Population: 5,06,71,017 (2001)

Capital: Gandhinagar

Language: Gujarati and Hindi

The present state of Gujarat came into being on Ist May, 1960. It is bounded by Pakistan and Rajasthan in the north, Madhya Pradesh in the east and Maharashtra in the south, while the Arabian Sea lies to its south **(Fig. 12.7)**.

Districts: 1. Ahmadabad, 2. Amreli, 3. Anand, 4. Banaskantha, 5. Bharuch, 6. Bhavnagar, 7. Dahod, 8. Dang, 9. Gandhinagar, 10. Jamnagar, 11. Junagarh, 12. Kheda, 13. Kachchh, 14. Mehsana, 15. Narmada, 16. Navsari, 17. Panchmahals, 18. Patan, 19. Porbandar, 20. Rajkot, 21. Sabarkantha, 22. Surat, 23. Surendranagar, 24. Tapi, 25. Vadodra, 26. Valsad.

Agriculture: Gujarat is one of the main producers of paddy, wheat, *bajra*, oilseeds, *isabgol*, cotton, groundnut, tobacco oilseeds and pulses.

Irrigation and Power: The total irrigation potential through surface water as well as ground water has been assessed at 64.88 lakh hectares including 17.92 lakh hectares through Sardar Sarover (Narmada) Project. The total irrigation potential created up to 2007 is worked out 42.26 lakh hectares.

Industries: Gujarat has highly diversified industries, having the registered factories about 23,300 (2008). It has industries like chemicals, petrochemicals,textiles, fertilizers, engineering, and electronics.

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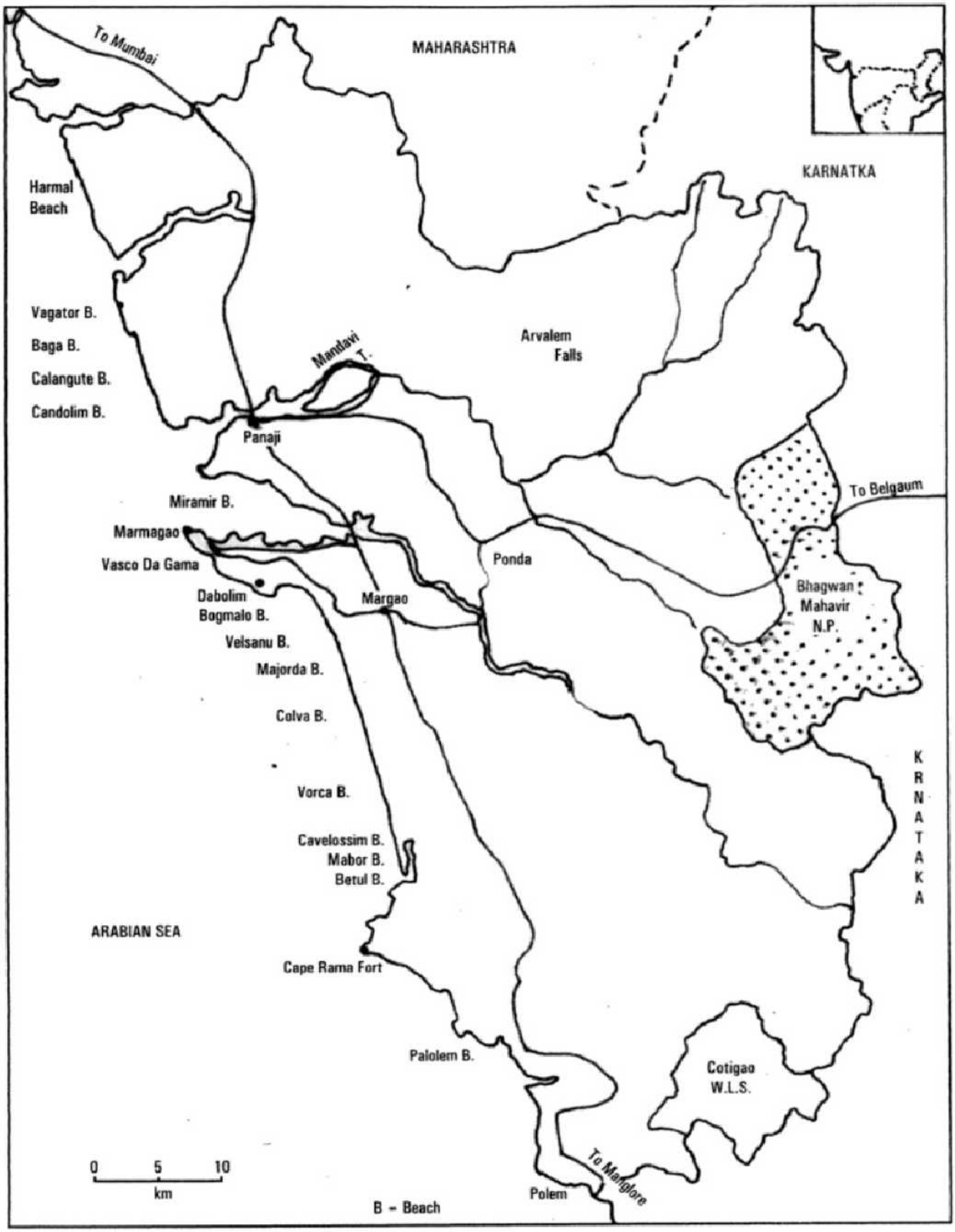

Fig. 12.5 – Chhattishgarh

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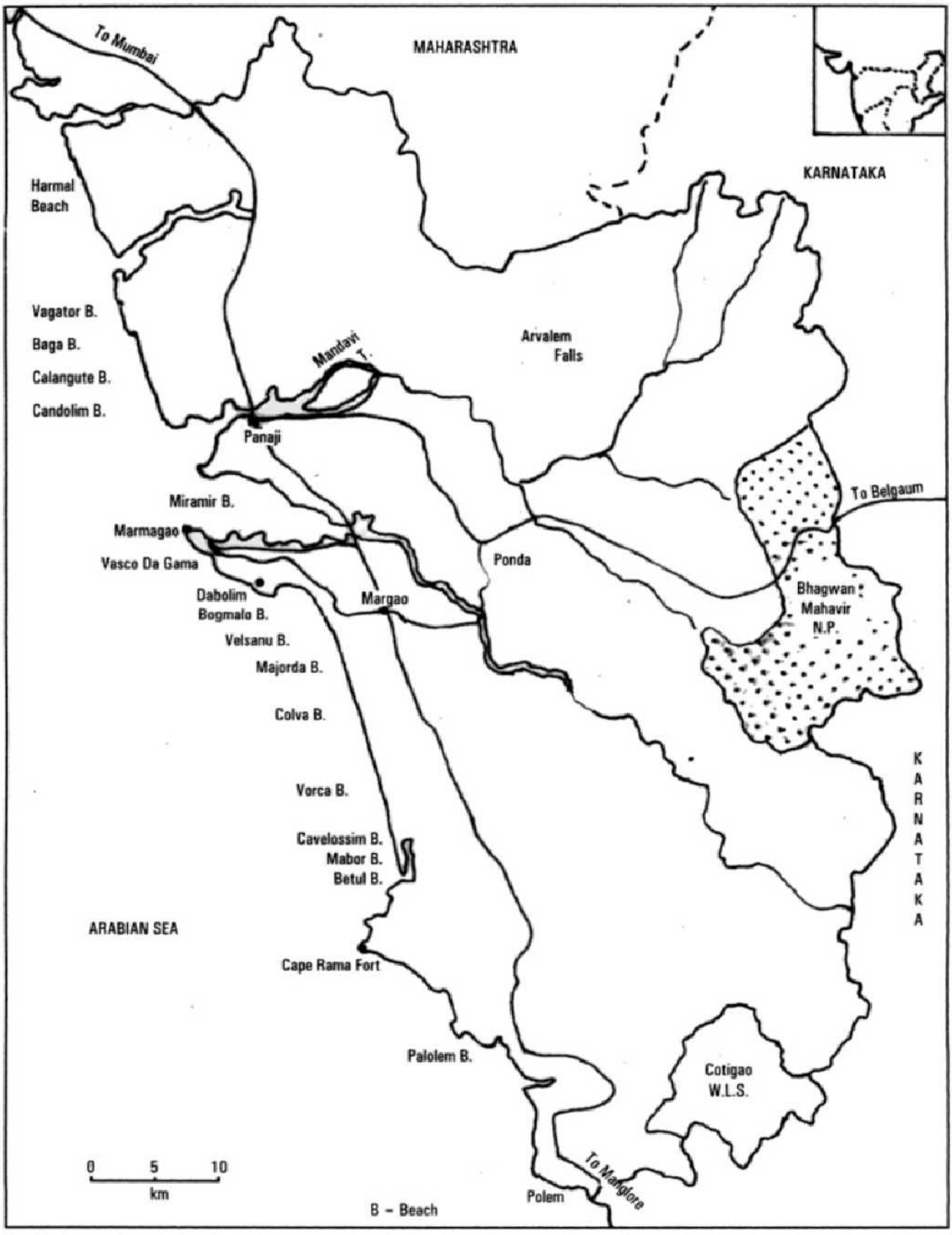

Fig. 12.6 – Goa.

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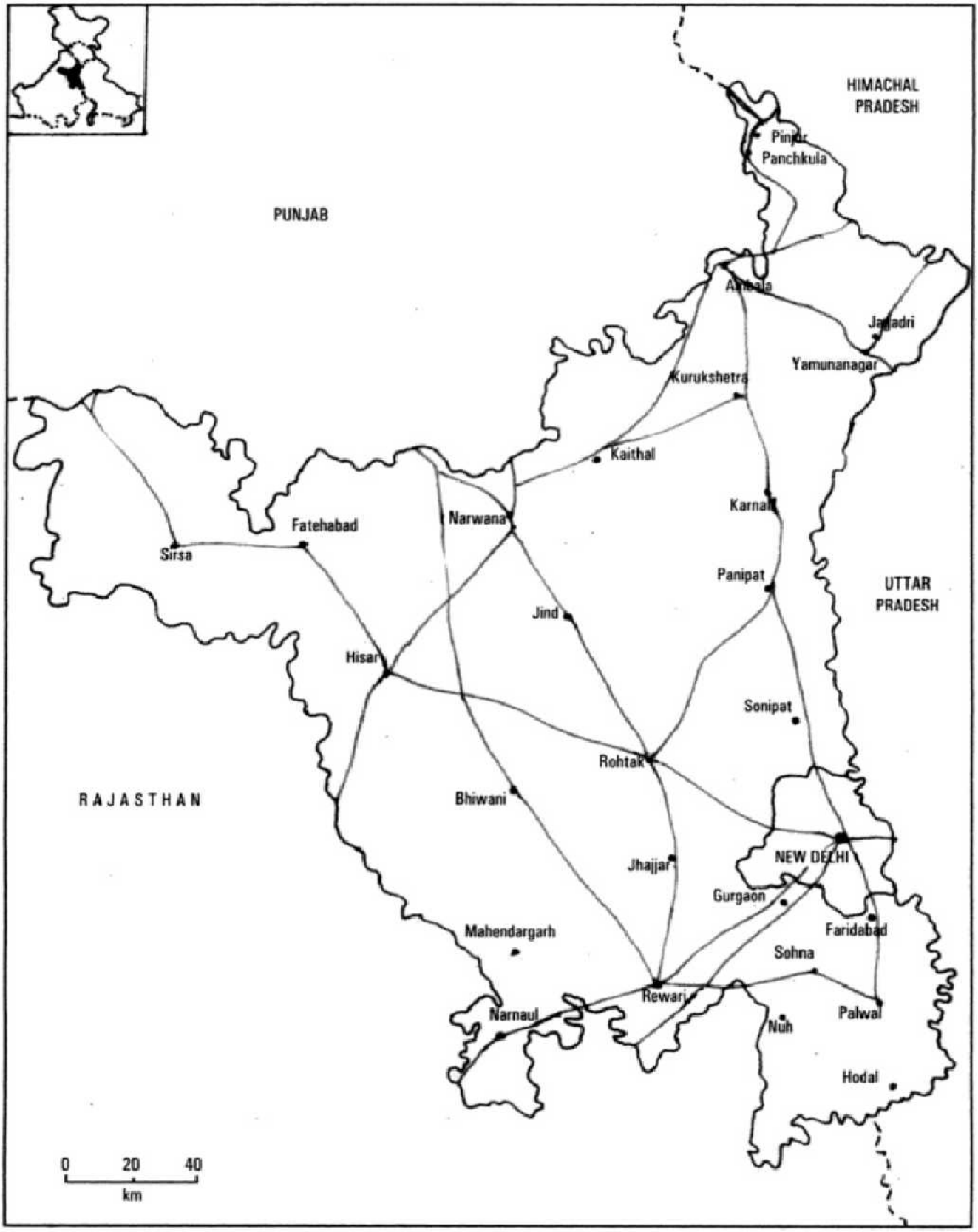

Fig. 12.9 – Haryana

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Fig. 12.10 – Himachal Pradesh

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Tawi (Jammu) are the main rivers of the Jammu and Kashmir state. The Dul-Hasti, Baghliar, and Salal (Chenab River), Upper Sindh Project (a tributary of Jhelum), and Uri Barrage are the main hydel projects of the state. Dal, Wular, Pangong Tso, Spanggur Tso, and Tso Moriri are the main lakes of the state.

Agriculture: About 80 per cent of the total population of the state is dependent on agriculture. Paddy, wheat, maize and oilseeds are the major crops. Barley, *bajra*, *jowar* and saffron are cultivated in some parts. Gram is grown in Laddakh. The area under orchards is 242 lakh hectares. The state produces fruit worth Rs. 2000 crore annually including export of walnuts worth Rs.120 crore. The state of Jammu and Kashmir has been declared as Agro-Export Zone. Its main fruits include apples, peaches, plums, cherries, strawberries, *Zeera*, saffron, apricots, almond, walnut, mango, guava, litchi and floriculture (tulips and roses). Coal is found at Junglegali and Kalakot (Jammu Division). Other minerals include copper, lead, zinc, nickel, manganese, gold, gypsum, sapphire and topaz.

Industry: Kashmir is famous for its delicate handicrafts. There are numerous small scale and cottage industries engaged in carpet and shawl making, embroidery, silver, copper ware, carving on walnut, decorative pieces and painting.

Tourist Centres: Kashmir Valley is described as the paradise on Earth. Chashmashahi Springs, Dachigam (National Park), Dal Lake, Gulmarg, Shalimar Bagh, Jawahar Tunnel, Mughal Gardens, Nishat-Bagh, Sonmarg, Verinag, Yusmarg, Amarnath shrine in Kashmir and Leh are great attractions for tourists. Vaishnodevi shrine and Patnitop near Jammu and Buddhist monasteries in Ladakh are also the important destinations for tourists. Ladakh festival on 15th September and Sindhu Darshan in June are popular events.

11. Jharkhand

Area: 79,714 sq km

Population: 32,966,238 (2011)

Capital: Ranchi

Languages: Hindi and Santhali

The state of Jharkhand was carved out of Bihar on 15th November 2000 as the 28th state. It is bounded by Bihar in the north, West Bengal in the east, Odisha in the south and Uttar Pradesh, Madhya Pradesh and Chhattisgarh in the west **(Fig. 13.11)**.

Districts: 1. Bokaro, 2. Chatra, 3. Deograh, 4. Dhanbad, 5. Dumka, 6. Garhwa, 7. Giridhih, 8. Godda, 9. Gumla, 10. Hazaribagh, 11. Jamtara, 12. Khunti, 13. Kodarma, 14. Latehar, 15. Lohardaga, 16. Pakur, 17. Palamau, 18. Paschami Sighbhum, 19. Purbi-Singhbhum, 20. Ramgarh, 21. Ranchi, 22. Sahibganj, 23. Sarai Kela, 24. Simdega.

Agriculture: Agriculture and allied activities are the major source of Jharkhand's economy. The total cultivated land is only 38 lakh hectares.

Industry Centres: Being situated in the Chhotanagpur Plateau, the state is known for valuable metallic, nonmetallic and coal resources. Some of the important industries located in the state are Bokaro Steel Plant in the public sector, Tata Iron and Steel Company (TISCO) in Jamshedpur in the private sector. Other important industries are Tata Engineering and Locomotive Company (Jamshedpur), Bharat Coking Limited (Dhanbad), Khilari Cement Factory (Palamau), Hindustan Copper Limited (Mussabani), and Hindalco Bauxite (Lohardaga), etc.

Tourist Centres: There are many scenic attractions in the state. *Lodh Waterfalls* (Budh River-near Ranchi), Chachro Crocodile Breeding Centre-Koderma (Tilaya Dam), Dalma Wildlife Sanctuary (Jamshedpur), Betla National Park, Chandrapur Bird Sanctuary.

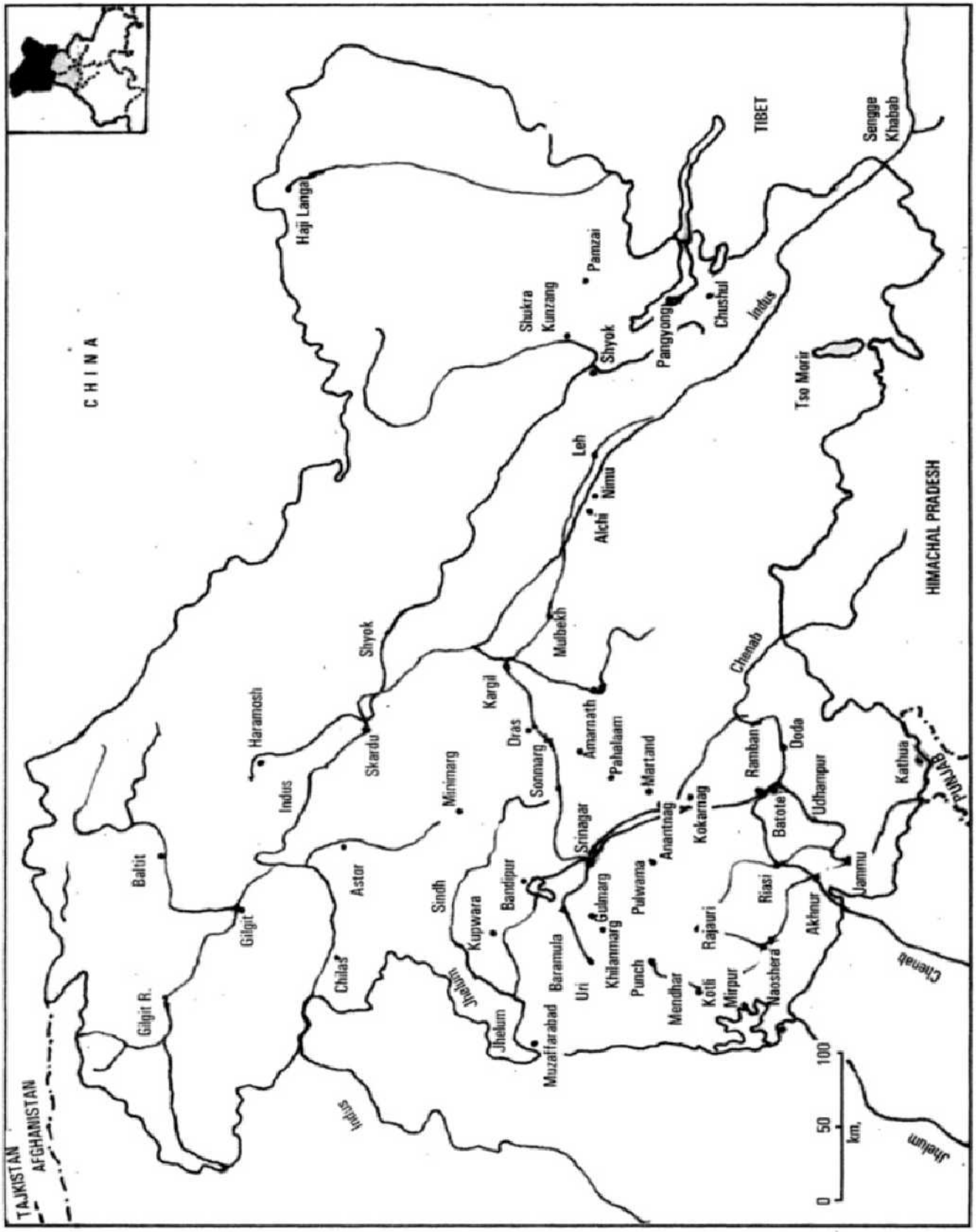

Fig. 12.11 – Jammu & Kashmir

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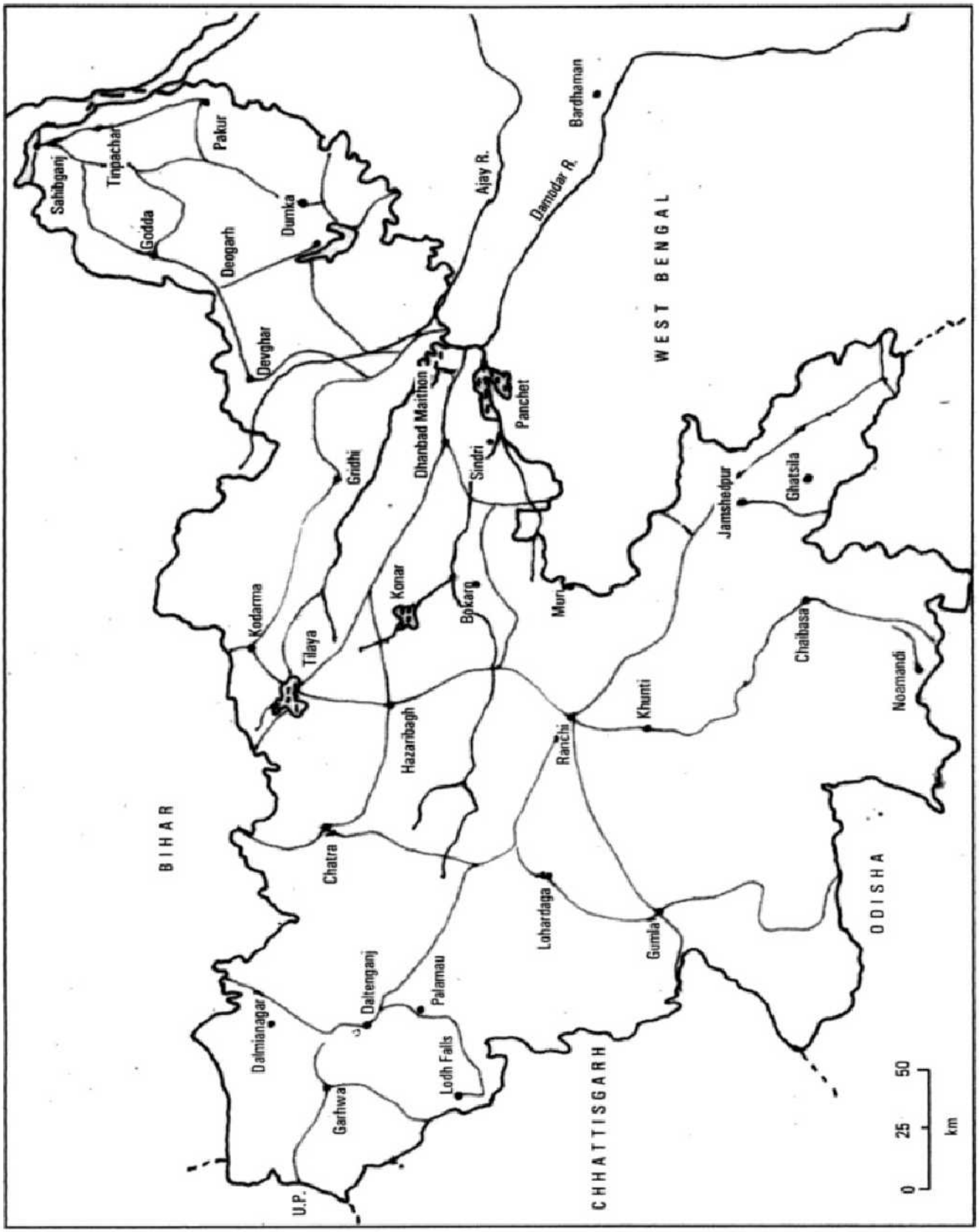

Fig. 12.12 – Jharkhand

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Tourist Centres: Kerala has emerged as one of the most important acclaimed tourist destinations in the country. Beaches, warm weather, back-waters, hill stations, waterfalls, wild-life, Ayurveda treatment year round festivals and diverse flora and fauna make Kerala a unique destination for tourists.

Industry: The main industries of Kerala include handloom, cashew, coir, and handicrafts. Other important industries include rubber, tea, ceramics, electric and electronic appliances, telephone cables, transformers, bricks, tiles, drugs and chemicals, general engineering, plywood and veneers, *beedi* and cigar, soaps, oils, fertilizers, *khadi* and village industry products. There are a number of manufacturing units for the production of precision instruments, machine tools, petroleum products, paints, pulp, paper, newsprint, glass and non-ferrous metals. The principal export products are cashewnut, tea, coffee, spices, lemon, grass-oil, sea-foods, rose- wood and coir. The state has an abundance of important minerals like ilmenite, rutile, monazite, zircon, sillimanite, clay and quartz sand.

14. Madhya Pradesh

Area: 3,08,000 sq km

Population: 6,03,85,118 (2001)

Capital: Bhopal

Languages: Hindi, Urdu

The state of Madhya Pradesh is bounded by Uttar Pradesh in the north, Jharkhand and Chhattisgarh in the east, Maharashtra in the south and Gujarat and Rajasthan in the west **(Fig. 12.15)**.

Districts: 1. Ashoknagar, 2. Anupnagar, 3. Barwani, 4. Balaghat, 5. Betul, 6. Bhind, 7. Bhopal, 8. Burhanpur, 9. Chhatarpur, 10. Chindwara, 11. Damoh, 12. Datia, 13. Dewas, 14. Dhar, 15. Dindori, 16. East Nimar, 17. Guna, 18. Gwalior, 19. Harda, 20. Hoshingabad, 21. Indore, 22. Jabalpur, 23. Jhabua, 24. Katni, 25. Mandla, 26. Mandsaur, 27. Morena, 28. Narsinghpur, 29. Neemuch, 30. Panna, 31. Raisen, 32. Rajgarh, 33. Ratlam, 34. Rewa, 35. Sagar, 36. Satna, 37. Sehore, 38. Seoni, 39. Shahdol, 40. Shajapur, 41. Sheopur, 42.Shivpuri, 43. Sidhi, 44. Tikamgarh, 45. Ujjain, 46. Umaria, 47. Vidisha, 48. West Nimar.

Agriculture: About 75 per cent of the total working force of Madhya Pradesh is directly or indirectly dependent on agriculture. Wheat, rice, pulses, soybean, maize, millets, and cotton are the main crops. The National Horticulture Mission has been implemented in 20 districts of the state. A separate Horticulture and Food Processing Department has been set up the net area irrigated under irrigation was over 6 million hectares in the year 2009-2010 of the total cultivated area.

Industries: Madhya Pradesh is a mineral rich state. The main minerals are coal, dolomite, limestone, bauxite, copper, diamond and precious stones. Madhya Pradesh has entered the era of high-tech industries like electronics, telecommunications, automobiles, and information technology. The state produce optical fibre for telecommunication needs. A large number of automobile industries have been established at Pithampur near Indore. The main industries in the public sector in the state are Bharat Heavy Electricals Ltd. at Bhopal, paper mill at Hoshingabad, bank notes at Dewas, news print factory at Nepanagar and alkaloid factory at Neemuch. The state is famous for its traditional handicrafts and handloom cloth manufactured in Chanderi, and Maheshwar.

Tourist Centres: The important tourist centres of Madhya Pradesh include Amarkantak, Bandhavgarh National Park, Bhimbetika, Bhopal, Chenderi, Dhunwadhar Falls, Indore, Kanha National Park, Sanchi, Panchmarhi, and Ujjain.

15. Maharashtra

Area: 3,07,713 sq km

Population: 112.4 million (2011)

Capital: Mumbai

Languages: Marathi, Hindi, Konkani

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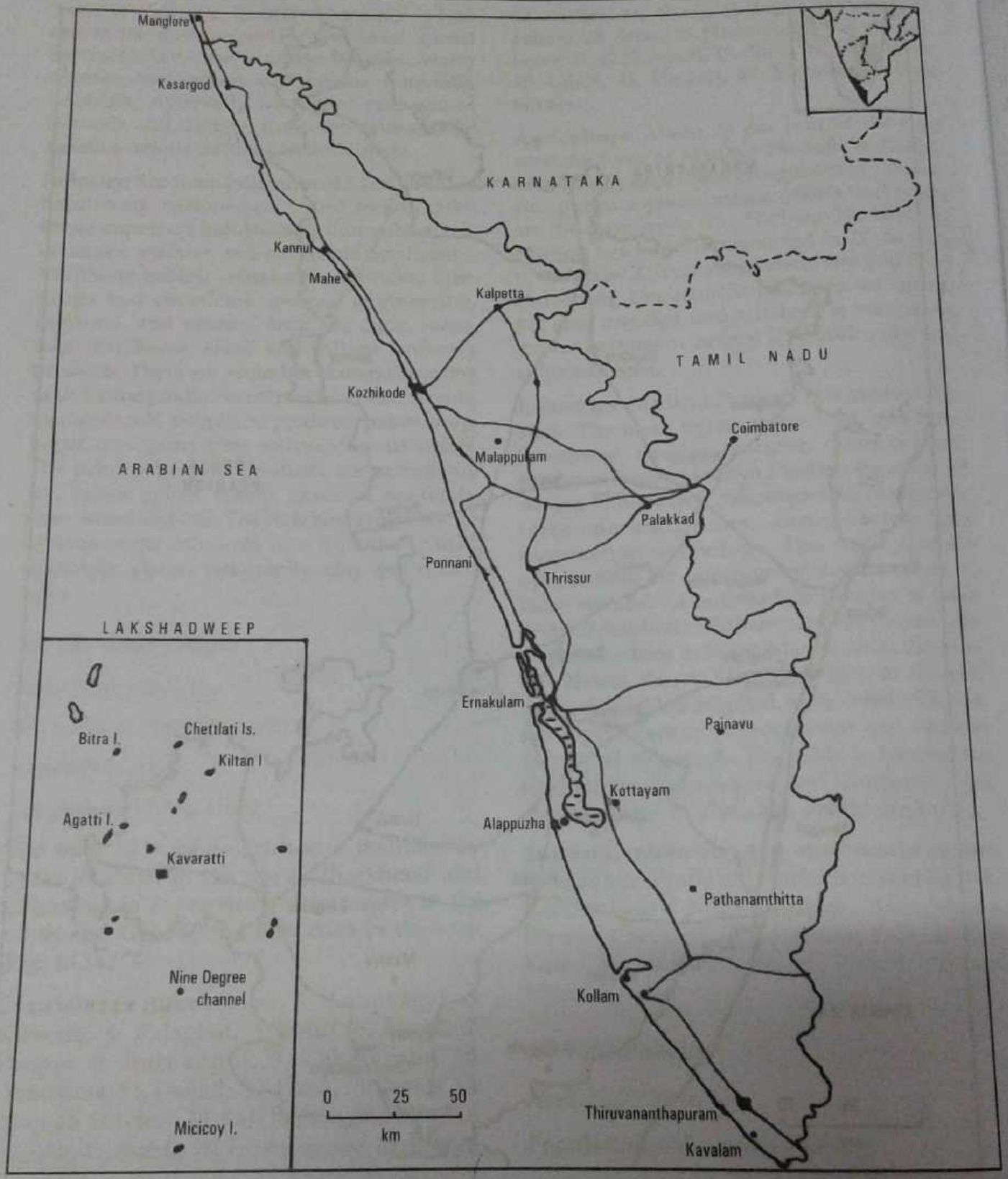

Fig. 13.13 – Kerala

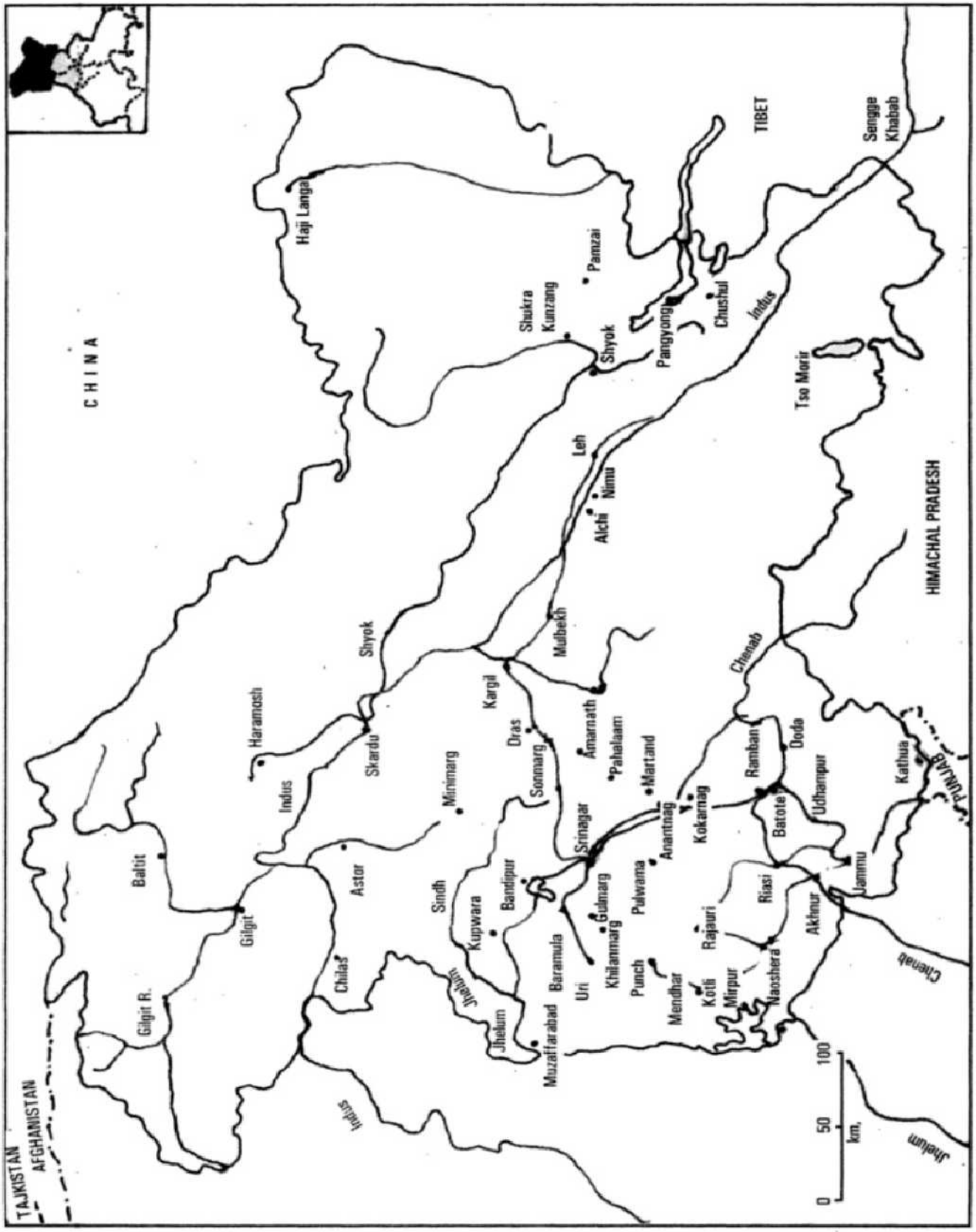

Fig. 12.11 – Jammu & Kashmir

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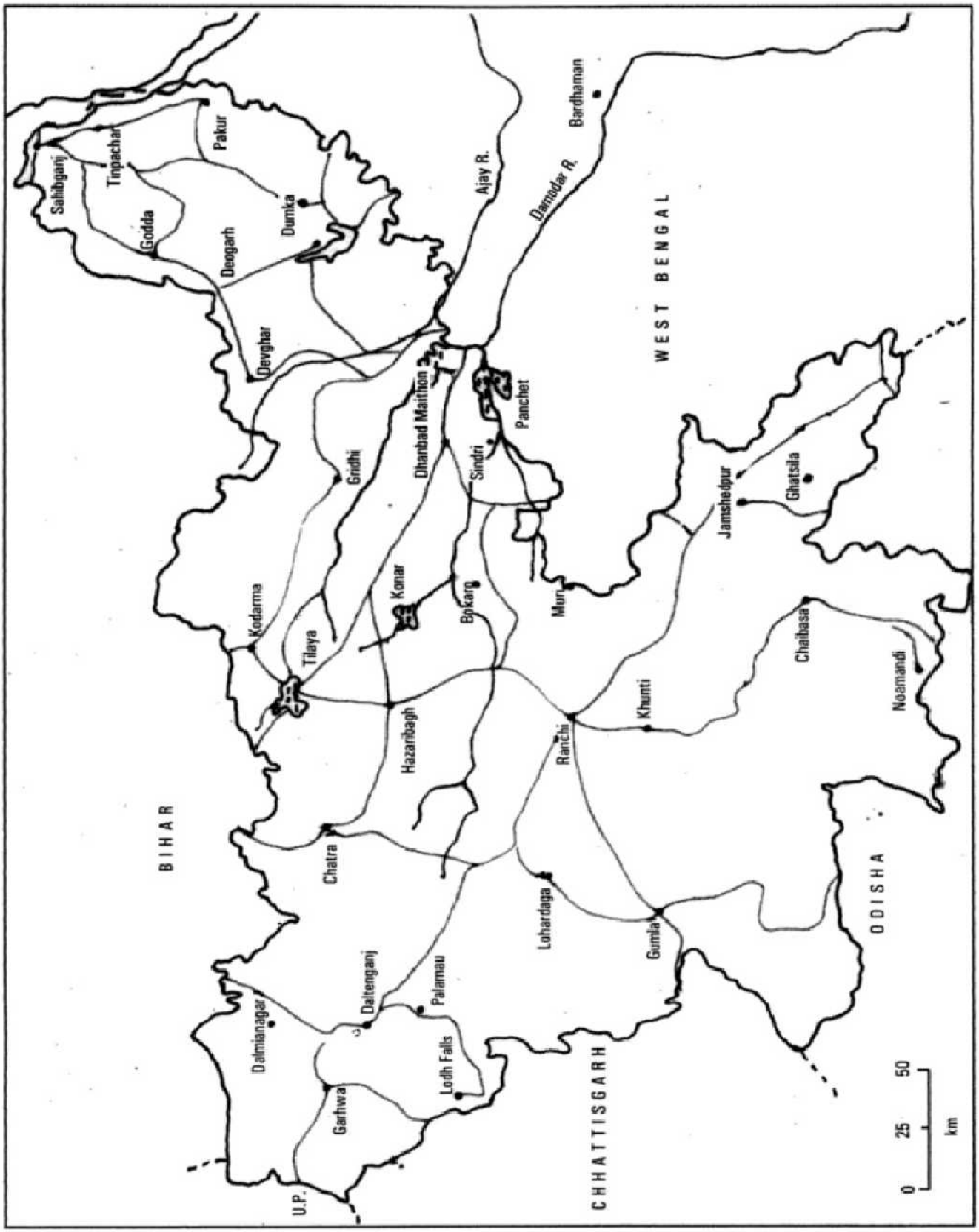

Fig. 12.12 – Jharkhand

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Industry: The main industries of Kerala include handloom, cashew, coir, and handicrafts. Other important industries include rubber, tea, ceramics, electric and electronic appliances, telephone cables, transformers, bricks, tiles, drugs and chemicals, general engineering, plywood and veneers, *beedi* and cigar, soaps, oils, fertilizers, *khadi* and village industry products. There are a number of manufacturing units for the production of precision instruments, machine tools, petroleum products, paints, pulp, paper, newsprint, glass and non-ferrous metals. The principal export products are cashewnut, tea, coffee, spices, lemon, grass-oil, sea-foods, rose- wood and coir. The state has an abundance of important minerals like ilmenite, rutile, monazite, zircon, sillimanite, clay and quartz sand.

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Population: 6,03,85,118 (2001)

Capital: Bhopal

Languages: Hindi, Urdu

The state of Madhya Pradesh is bounded by Uttar Pradesh in the north, Jharkhand and Chhattisgarh in the east, Maharashtra in the south and Gujarat and Rajasthan in the west **(Fig. 12.15)**.

Districts: 1. Ashoknagar, 2. Anupnagar, 3. Barwani, 4. Balaghat, 5. Betul, 6. Bhind, 7. Bhopal, 8. Burhanpur, 9. Chhatarpur, 10. Chindwara, 11. Damoh, 12. Datia, 13. Dewas, 14. Dhar, 15. Dindori, 16. East Nimar, 17. Guna, 18. Gwalior, 19. Harda, 20. Hoshingabad, 21. Indore, 22. Jabalpur, 23. Jhabua, 24. Katni, 25. Mandla, 26. Mandsaur, 27. Morena, 28. Narsinghpur, 29. Neemuch, 30. Panna, 31. Raisen, 32. Rajgarh, 33. Ratlam, 34. Rewa, 35. Sagar, 36. Satna, 37. Sehore, 38. Seoni, 39. Shahdol, 40. Shajapur, 41. Sheopur, 42.Shivpuri, 43. Sidhi, 44. Tikamgarh, 45. Ujjain, 46. Umaria, 47. Vidisha, 48. West Nimar.

Agriculture: About 75 per cent of the total working force of Madhya Pradesh is directly or indirectly dependent on agriculture. Wheat, rice, pulses, soybean, maize, millets, and cotton are the main crops. The National Horticulture Mission has been implemented in 20 districts of the state. A separate Horticulture and Food Processing Department has been set up the net area irrigated under irrigation was over 6 million hectares in the year 2009-2010 of the total cultivated area.

Industries: Madhya Pradesh is a mineral rich state. The main minerals are coal, dolomite, limestone, bauxite, copper, diamond and precious stones. Madhya Pradesh has entered the era of high-tech industries like electronics, telecommunications, automobiles, and information technology. The state produce optical fibre for telecommunication needs. A large number of automobile industries have been established at Pithampur near Indore. The main industries in the public sector in the state are Bharat Heavy Electricals Ltd. at Bhopal, paper mill at Hoshingabad, bank notes at Dewas, news print factory at Nepanagar and alkaloid factory at Neemuch. The state is famous for its traditional handicrafts and handloom cloth manufactured in Chanderi, and Maheshwar.

Tourist Centres: The important tourist centres of Madhya Pradesh include Amarkantak, Bandhavgarh National Park, Bhimbetika, Bhopal, Chenderi, Dhunwadhar Falls, Indore, Kanha National Park, Sanchi, Panchmarhi, and Ujjain.

15. Maharashtra

Area: 3,07,713 sq km

Population: 112.4 million (2011)

Capital: Mumbai

Languages: Marathi, Hindi, Konkani

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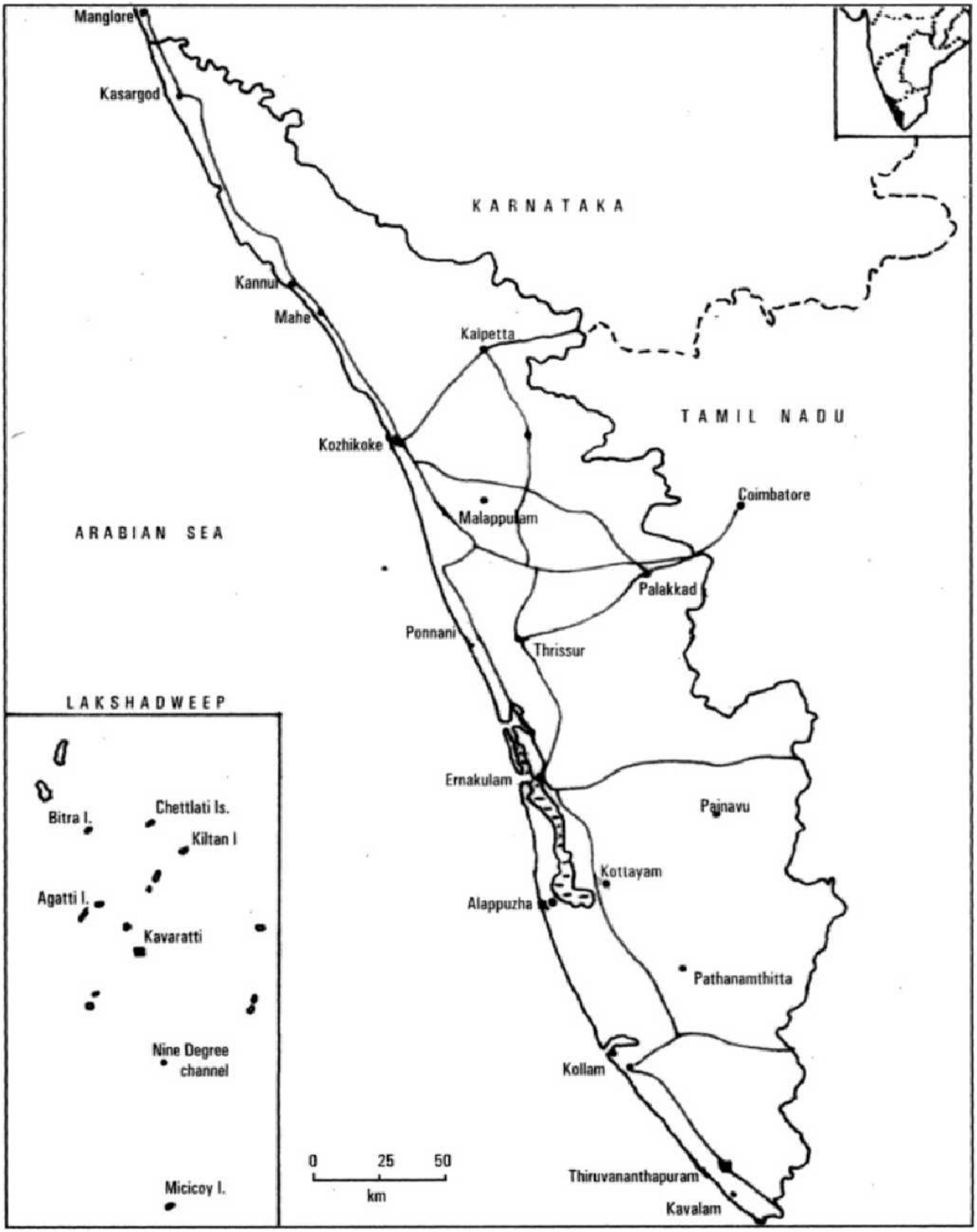

Fig. 12.14 – Kerala

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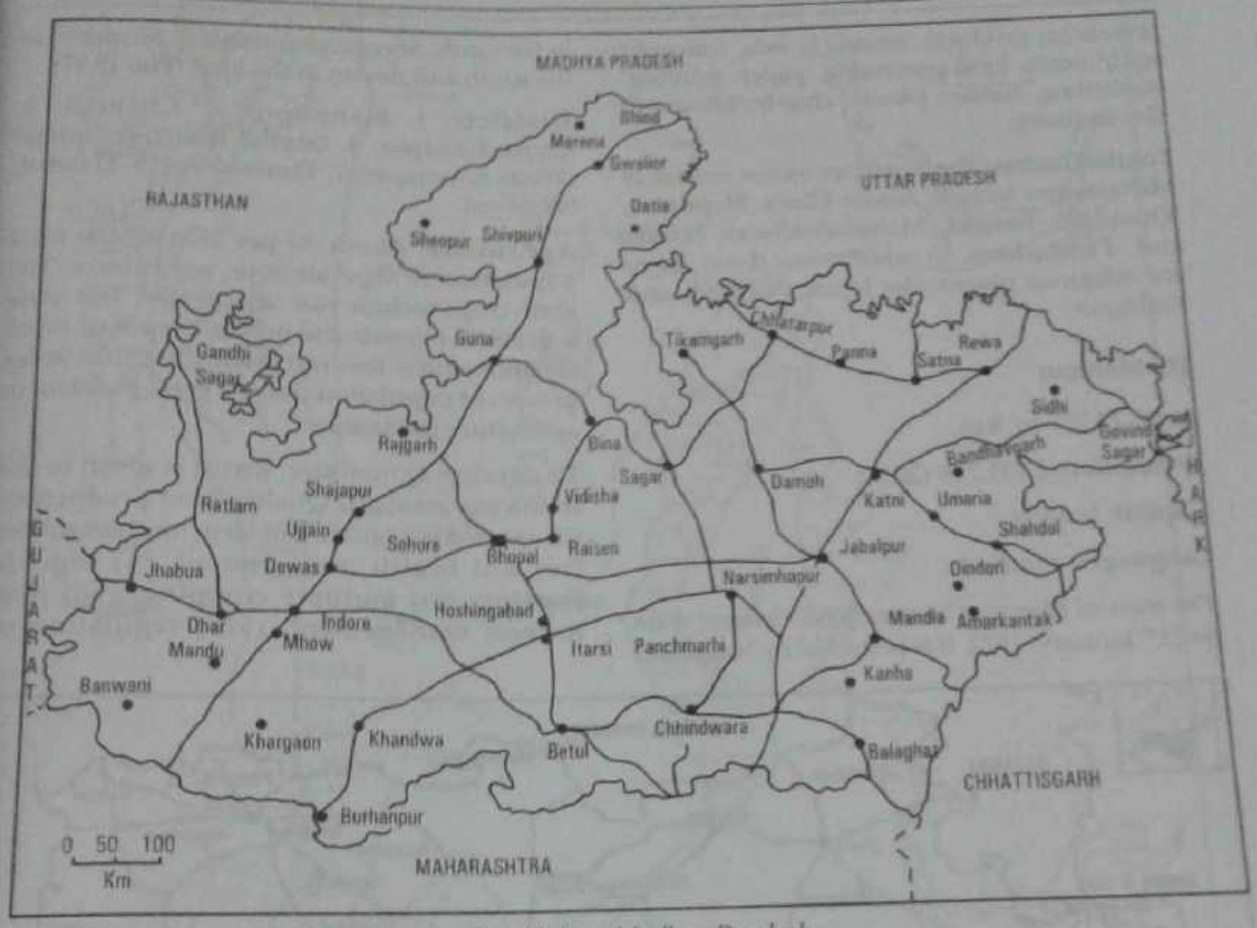

Fig. 13.14 – Madhya Pradesh

The state of Maharashtra is bounded by Gujarat and Madhya Pradesh in the north, Chhattisgarh and Andhra Pradesh in the east, Karnataka and Goa in the south, while to the west lies the Arabian Sea **(Fig. 13.15)**.

District: 1. Ahmednagar, 2. Akola, 3. Amravati, 4. Aurangabad, 5. Bhandara, 6. Beed, 7. Buldhana, 8. Chandrapur, 9. Dhule, 10. Gadchiroli, 11. Gondia, 12. Hingoli, 13. Jalgaon, 14. Jalna, 15. Kolhapur, 16. Latur, Mumbai City, 17. Mumbai-suburb. 18. Nagpur, 19. Nanded, 20. Nasik, 21. Nandubar, 22. Osmanabad, 23. Prabhani, 24. Pune, 25. Raigad, 26. Ratnagiri, 27. Sangli, 28. Satara, 29. Sindhudurg, 30. Solapur, 31. Thane, 32. Wardha, 33. Washim, 34. Yavatmal.

Agriculture: About 65 per cent of the total population of Maharashtra is directly or indirectly dependent on agriculture. The main crops of Maharashtra are rice, *jowar*, maize, cotton, wheat, *Tur* (pegion-pea), *Urad* (black-gram), gram, soybean, sugarcane, oilseeds, groundnut, sunflower, turmeric, vegetables, fruits (mango, banana, orange, grape, papaya and cashewnut, etc.).

Industry: Mumbai the financial capital of the country, is located in Maharashtra.The main urban sprawl of Mumbai is between the Thane Creek and the Arabian Sea **(Fig. 13.16)**. The main industries of Maharashtra include cotton textile, automobiles, jeeps, electric machinery,

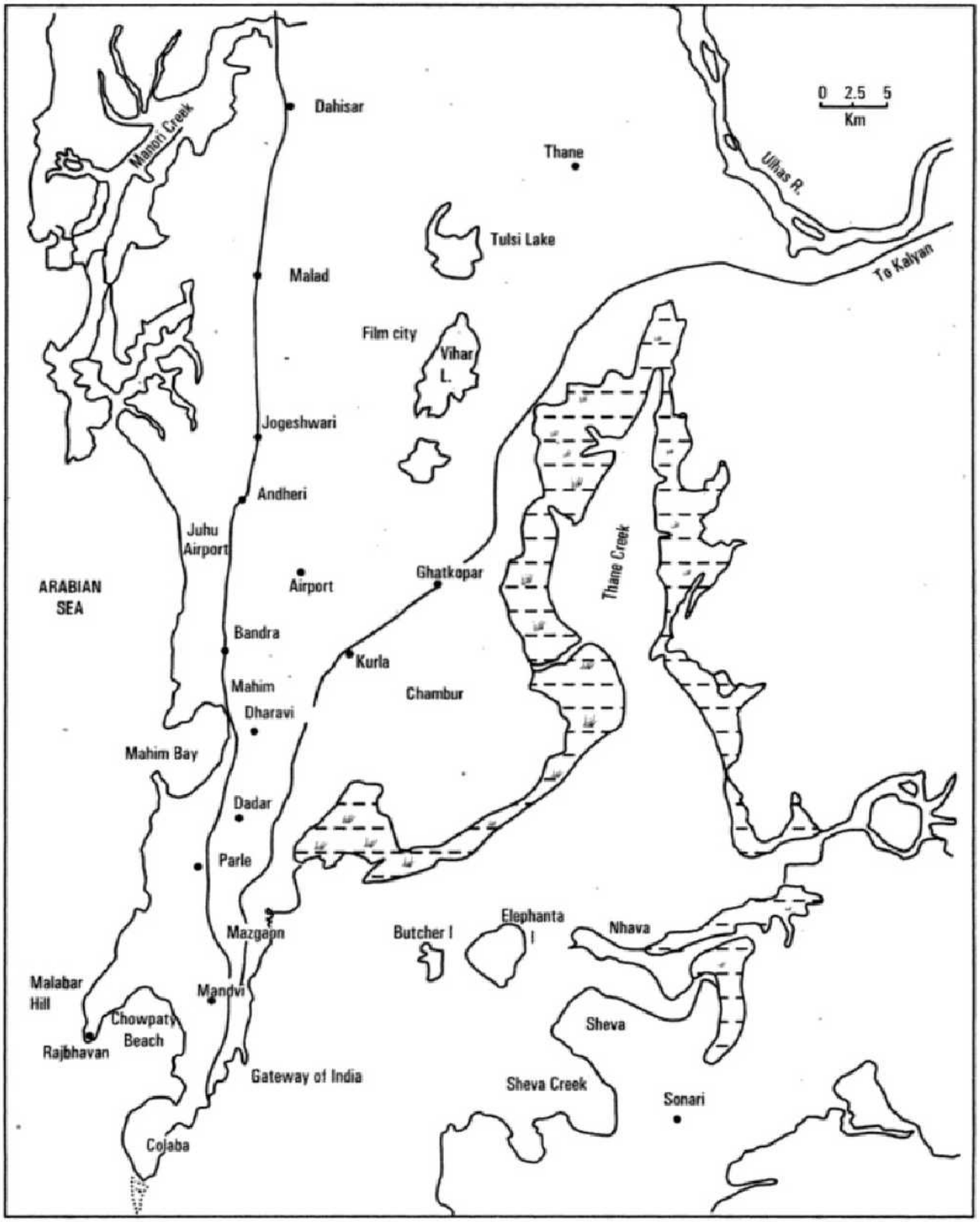

Fig. 12.17 – Greater Mumbai

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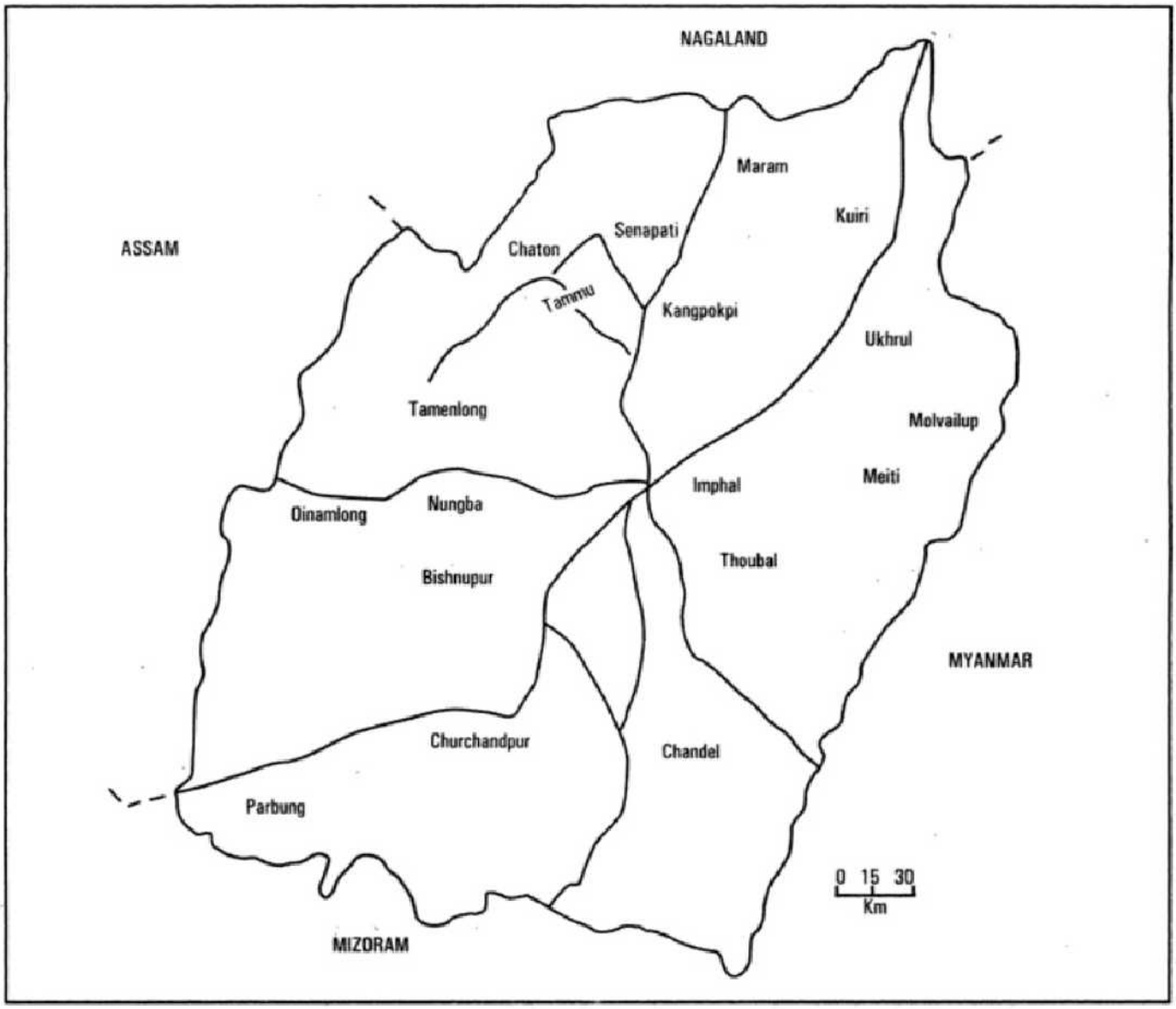

FIG. 12.18 – Manipur

management, (viii) regulation of markets, (ix) research and development in biotechnology, (x) application of information technology, (xi) transfer of technology: (a) establishment of Farms Field School in each district, and (b) extension management.

Irrigation: The main irrigation and hydel projects in Manipur are Loktak Hydro-Electric Project, Kopili Hydro-Electric Project, Khnadong Hydro-Electric Project, Doyang HE Project, Kathalguri and Ramachandranagar Projects, Thoubal Project, Sinsoda Multipurpose Project, Khuga Multipurpose Project, and Dolaithabi Barrage.

Tourist Centres:

The main tourist places are Loktak Lake, Kaibul Lamjao National Park, and Siroy Hills.

17. Meghalaya

Area: 22,429 sq km

Population: 23,18, 822 (2001)

Capital: Shillong

Languages: Khasi and Garo

The state of Meghalaya is bounded by Assam in the north and east, and Bangladesh in the south and west **(Fig. 12.19)**.

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Districts: 1. East Garo Hills, 2. East Khasi Hills, 3. Jaintia Hills, 4. Ri-Bhoi (Nongpoh), 5. South Garo Hills, 6. West Garo Hills, 7. West Khasi Hills.

Agriculture: Meghalaya is essentially an agricultural state in which about 80 per cent of the total population is dependent on agriculture. Rice, maize, pulses, oilseeds, potato, ginger, turmeric, black-pepper, arecanut, tapioca, sunflower, jute and mesta are the main crops. The state has a vast potential for the development of horticulture (pine-apple, jackfruit, plums, pears, peach, tea, coffee and cashewnut). In the hilly parts, Jhuming is practiced by the tribal farmers. This type of agriculture is detrimental to the environment and ecology.

Tourist Centres: Elephant Falls, Chirrapunji, Mawsynram, Bada-Pani are the important tourist places. The only airport in the state is Umroi, about 35 km from Shillong.

18. Mizoram

Area: 21,081, sq km

Population: 8,91,058 (2001)

Capital: Aizawl

Languages: Mizo and English

The state of Mizoram was created as the 23rd state of India in February, 1987. It is bounded by Assam and Manipur in the north, Myanmar in the east, and Bangladesh and Tripura in the west **(Fig. 12.20)**.

Districts: 1. Aizawl, 2. Champai, 3. Chhimtuipui (Shiha), 4. Kolasib, 5. Lawngtlai, 6. Lunglei, 7. Mamit, 8. Serchip.

Agriculture: About 80 per cent of the people of Mizoram is engaged in agriculture. *Jhuming* (shifting cultivation) is the main agricultural typology. Apart from rice and maize, Mizoram is known for pineapple, banana, oranges, grapes, papaya, ginger, turmeric, black-pepper, chillies, and vegetables.

Irrigation: The main irrigation and hyro-electric projects include Kolodyne, Tuirial HEP, Tuipanglui and Kau-Tlabung project.

Industries: The entire Mizoram is Notified Backward Area. The New Industrial Policy announced in 2000, identified the thrust areas like electronics, information technology, bamboo and timber based products.

Tourist Centres: The main tourist attractions include Aizawl, Vantawng Waterfalls, and Champai (a beautiful resort near Myanmar border).

19. Nagaland

Area: 16,579 sq km

Population: 19,88,636 (2001)

Capital: Kohima

Languages: Angami, Ao, Chang, Konyak, Lotha.

Nagaland, the 16th state of India was established on Ist December, 1963. It is bounded by Assam in the west and north, Myanmar in the east and Manipur in the south **(Fig. 12.21).**

Districts: 1. Dimapur, 2. Mokokchung, 3. Phek, 4. Wokha, 5. Kohima, 6. Mon, 7. Tuensang, 8. Zunheboto.

Agriculture: About 70 per cent of the population of Nagaland is directly or indirectly dependent on agriculture. The major agricultural land use is slash and burn (*Jhuming*).

Industry: The process of industrialisation is in the infancy stage. Nagaland has bricks making factory at Dimapur. Handloom and handicrafts are the important cottage industries. An industrial centre has emerged at Ganeshnagar near Dimapur Distirct.

Tourists Centres: Intanki and Puliebadze in Kohima District, Fakim in Tuensang District, and Rangapahar in Dimapur District.

20. Odisha

Area: 1,55,707 sq km

Population: 36,804,660 (2001)

Capital: Bhubaneshwar

Language: Oriya

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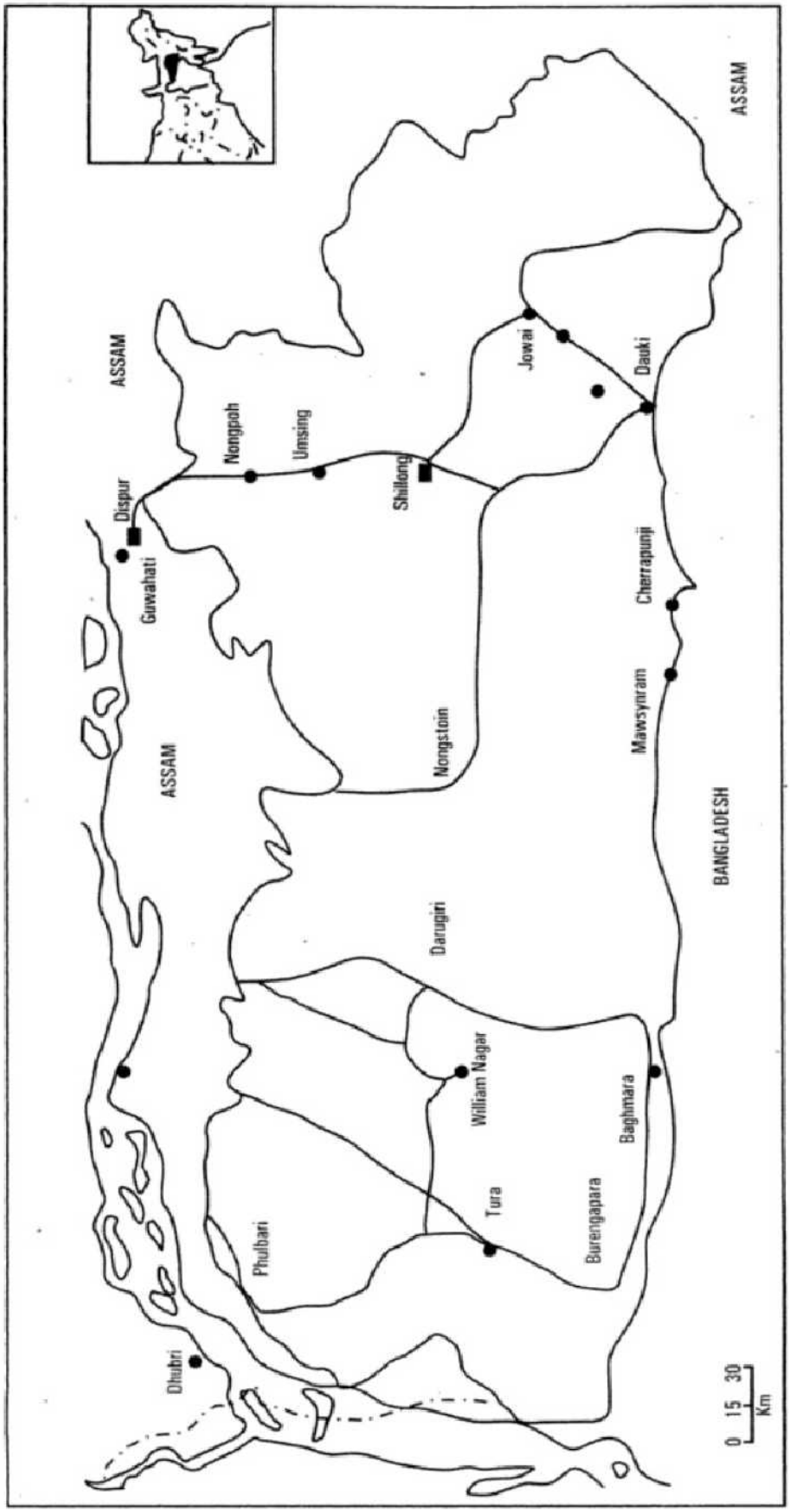

Fig. 12.19 – Meghalaya

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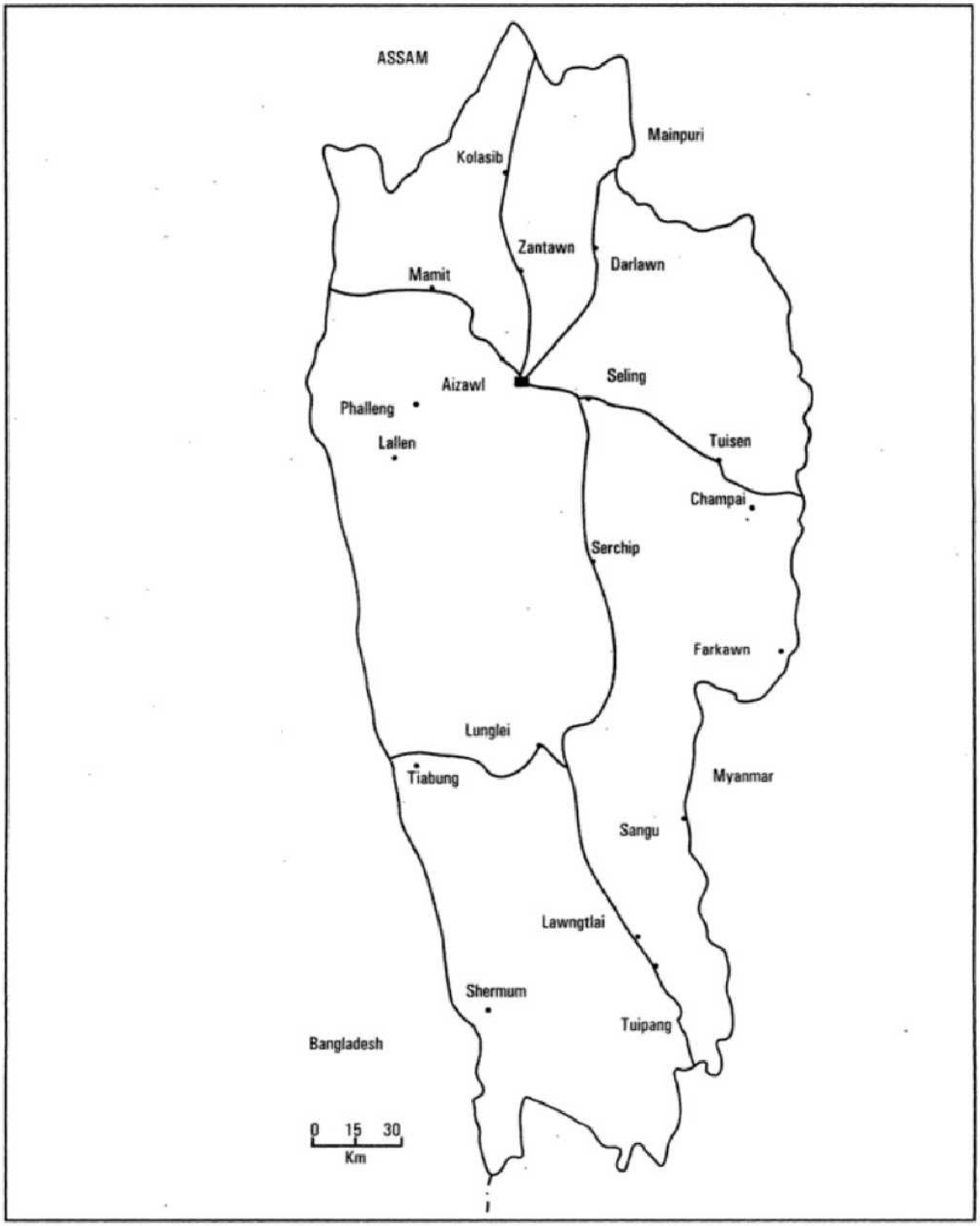

Fig. 12.20 – Mizoram

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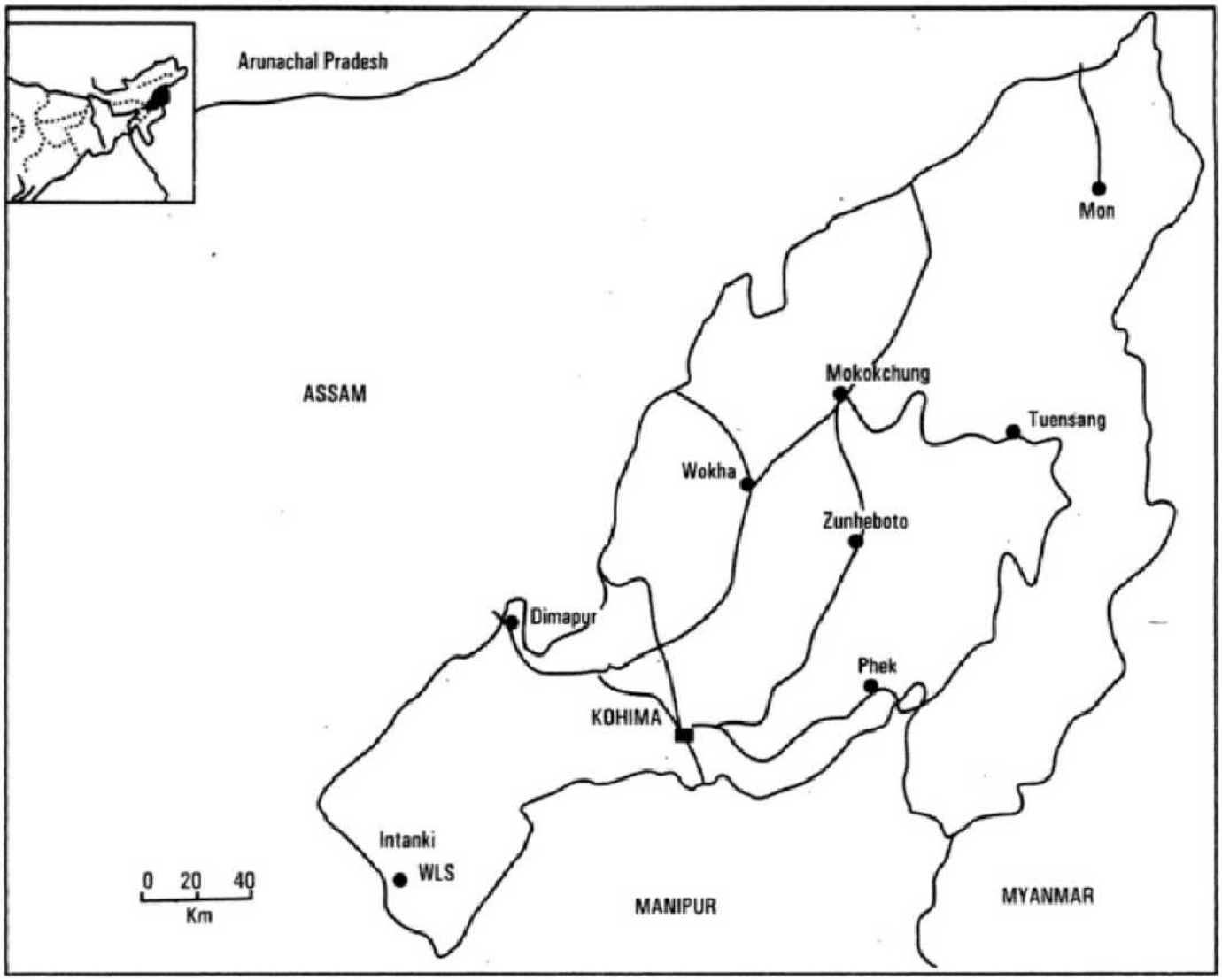

Fig. 12.21 – Nagaland

Odisha was known as Kalinga in ancient days. Odisha was made into a separate province on Ist April, 1936 and became a state in January, 1949. The state of Odisha is bounded by Jharkhand and West Bengal in the north, Chhattisgarh in the west, Andhra Pradesh in the south and the Bay of Bengal in the south and east **(Fig. 12.22)**.

Districts: 1. Angul, 2. Balsore, 3. Bargarh, 4. Bhadrak, 5. Bolangir, 6. Boudh, 7. Cuttack, 8. Deograh, 9. Dhenkanal, 10. Gajpati, 11. Ganjam, 12. Jagatsinghpur, 13. Jaipur, 14. Jarsuguda,15. Kalahandi, 16. Kandhamal, 17. Kendrapara, 18. Keonjhar, 19. Khurda, 20. Koraput, 21. Malkangiri, 22. Mayurbhanj, 23. Nawapara, 24. Nawarangpur, 25. Nayagarh, 26. Puri, 27. Rayagada, 28. Sambalpur, 29. Sonepur, 30. Sundergarh.

Agriculture: It engages 65 per cent of the work force, contributing about 26 per cent of the net domestic product. Rice, maize, sugarcane, pulses, oilseeds and vegetables are the main crops.

Ports: Among the eleven major ports in the country, Paradeep is the only port belonging to Odisha. Megaport Dharma has also been commenced. Gopalpur is going to be an all weather port for which work has already started.

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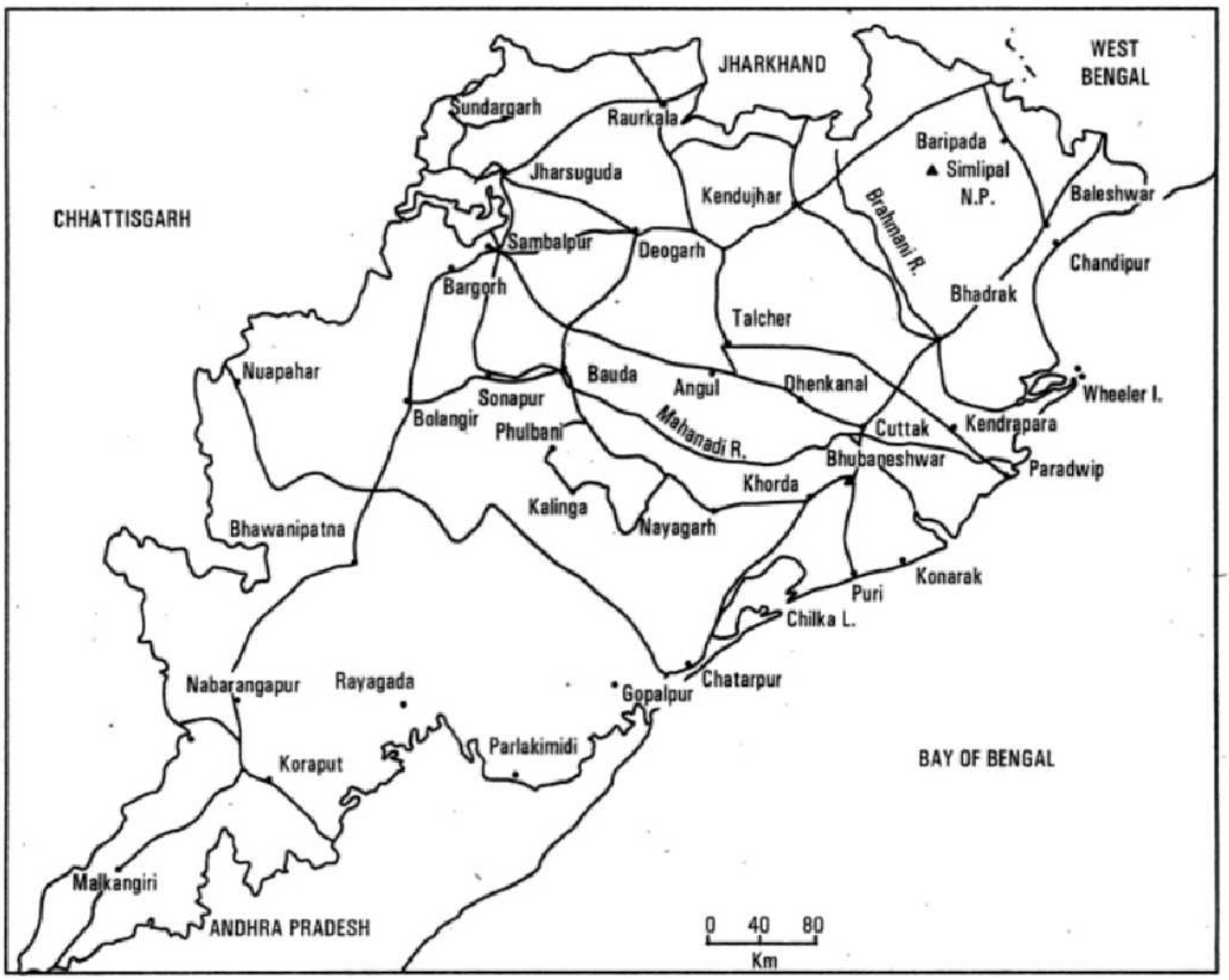

Fig. 12.22 – Odisha

20. Punjab

Area: 50,362 sq km

Population: 2,43,58, 999 (2001)

Capital: Chandigarh

Languages: Punjabi and Hindi

The state of Punjab is bounded by Pakistan in the west, Jammu & Kashmir and Himachal Pradesh in the north, Rajasthan, and Haryana in the south and east **(Fig. 12.23)**.

Districts: 1. Amritsar, 2. Barnala, 3. Bhatinda, 4. Faridkot, 5. Fatehgarh, 6. Firozpur, 7. Gurdaspur, 8. Hoshiarpur, 9. Jalandhar, 10. Kapurthala, 11. Ludhiana, 12. Mansa, 13. Moga, 14. Muktsar, 15. Patiala, 16. Roopnagar, 17. Sangrur, 18. Tarn Taran, 19. Sahibzada Ajit Singh Nagar (Mohali), 20. Shaheed Bhagat Singh Nagar (Nawanshahr).

Agriculture: The state has 84% of its total geographical area under cultivation. Its cropping intensity is around 189%. Having 1.5 per cent of the total area of the country, Punjab produces 20 per cent of wheat, 11 per cent of rice and 13 per cent of cotton of the country. It is known as the *'Food Basket and granary of India.,* The state of Punjab has been awarded the 'National Productivity Award for Agriculture, consecutively from 1991-92 to 1998-99, 2001-02 and 2003-04.

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Irrigation: Ranjit Sagar Dam is a multi-purpose river valley project which has been constructed 8 km upstream of Madhopur Head Works at the Ravi River. Among the other important projects are Bhakra Nangal, Harike Barrage, and Pong Dam at Beas.

Industries: Punjab is known for the production of bicycles, sewing machines, machine-tools, auto-parts, electrical goods, sports goods, surgical instruments, leather goods, hosiery, knitwear, nuts and bolts, textile, railway compartments, sugar, and vegetable oils.

The state has a large number of places of tourist interest. For example, the Golden Temple, Jalianwala Bagh, Anandpur Sahib, and Bhakra Dam.

22. Rajasthan

Area: 3,42,239 sq km

Population: 68,621,012 (2011)

Capital: Jaipur

Languages: Hindi and Rajasthani

The state of Rajasthan is bounded by Pakistan in the west, Punjab and Haryana in the north, Uttar Pradesh and Madhya Pradesh in the east and Gujarat in the south **(Fig. 13.23)**.

Districts: 1. Ajmer, 2. Alwar, 3. Banswara, 4. Baran, 5. Barmer, 6. Bharatpur, 7. Bhilwara, 8. Bikaner, 9. Bundi, 10. Chittaurgarh, 11. Churu, 12. Dausa, 13. Dhaulpur, 14. Dungarpur, 15. Ganganagar, 16. Hanumangarh, 17. Jaipur, 18. Jaisalmer, 19. Jalore, 20. Jhalwar, 21. Jhunjhnu, 22. Jodhpur, 23. Karauli, 24. Kota, 25. Nagaur, 26. Pali, 27. Pratapgarh, 28. Rajsamand, 29. Sawai Madhopur, 30. Sikar, 31. Sirohi, 32. Tonk, 33. Udaipur.

Agriculture: The main crops of Rajasthan are *bajra, jowar*, millet, rice, wheat, barley, gram, pulses, oilseeds, mustard, cotton, vegetables, red-chillies, cumin-seeds, *methi*, tobacco, and citrus fruits (mangoes, oranges, lemon, malta).

Irrigation: The irrigation projects include Kota Barrage, and Rana Pratap Sagar and Gandhi Sagar in Chambal Valley, Indira Gandhi Canal (Command area about 1.5 lakh hectare).

Minerals: Rajasthan has rich deposits of copper, zinc, lead, silver, mica, marble, emerald, granite, gypsum, asbestos, feldspar and building stones.

Industry: The important industries of Rajasthan include textiles, sugar, cement, glass, sodium plants, oxygen, vegetable dyes, pesticides, zinc, fertilizers, railway wagons, ball-bearings, water and electricity metres, sulphuric acid, television sets, synthetic yarn and insulating bricks. Besides precious and semi-precious stones, caustic soda, calcium carbide, nylon and tyres, etc. are the other important industrial units. The main industrial centres of Rajasthan include Zinc Smelter at Devari (Udaipur), Khetri-Nagar (Jhunjhunu), Precision Instruments Factory (Kota).

Tourist Centres: The important cities and places of tourist interest are Ajmer, Bikaner, Bharatpur, Chittaurgarh, Dholpur, Dungarpur, Jaipur, Jaisalmer, Jodhpur, Kishangarh, Kota, Udaipur, Mt. Abu, Pali and Udaipur.

23. Sikkim

Area: 7,096 sq km

Population: 607,688 (2011)

Capital: Gangtok

Languages: Lepcha, Bhutia, and Nepalis

Sikkim is a small state, bounded by vast stretches of Tibetan Plateaux in the north, the Chumbi Valley of Tibet and the Kingdom of Bhutan in the east, Nepal in the west and West Bengal in the south. The world's third highest mountain, Kangchendzong lies in Sikkim **(Fig. 13.24)**.

Districts: 1. East Gangtok, 2. South Namchi, 3. North Mangan, 4. West Gyalshing.

Agriculture: Sikkim is essentially an agrarian country. More than 64 per cent of the total population is dependent on agriculture. Maize, rice, wheat, potato, large cardamom, ginger and oranges are the main crops.

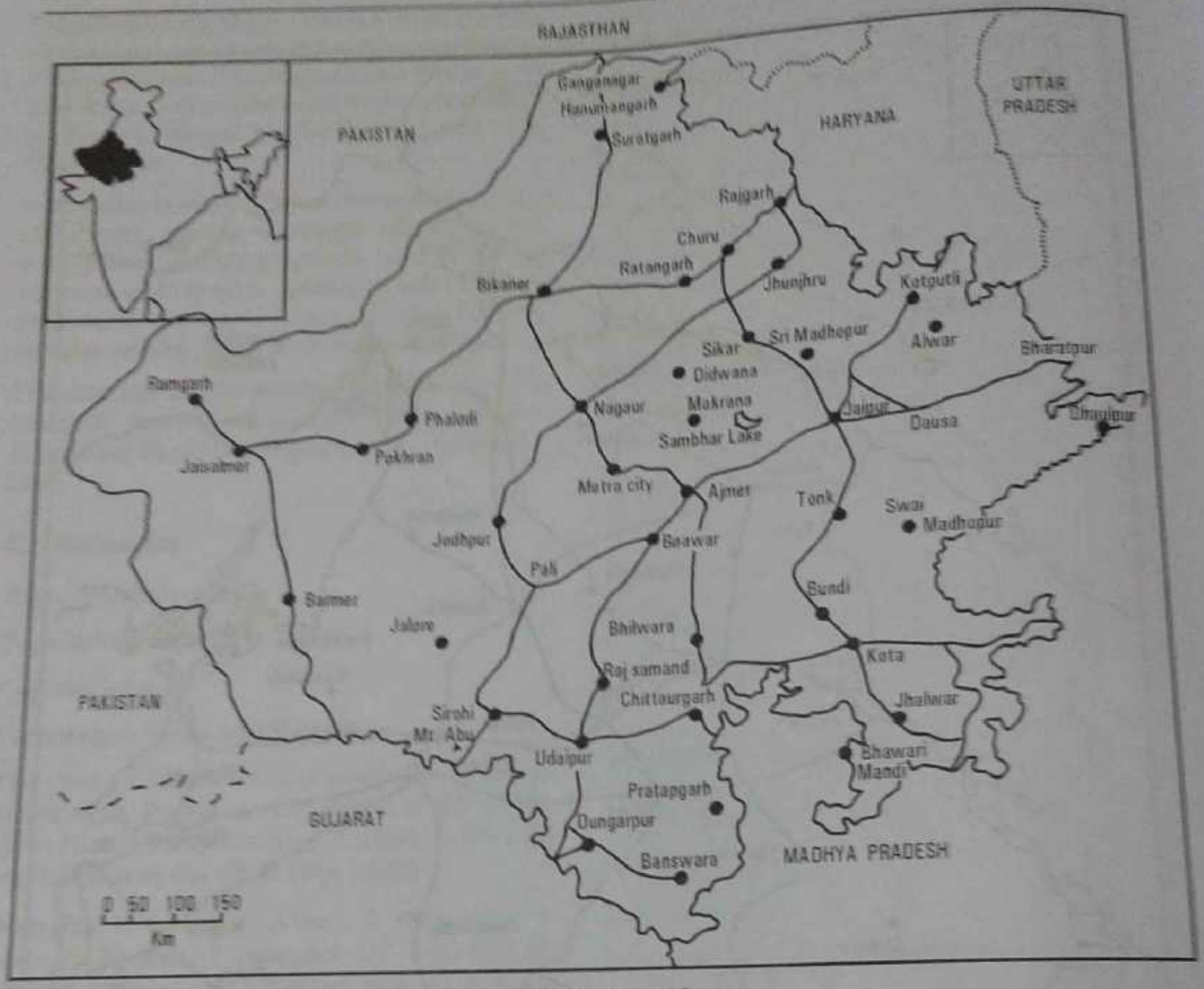

Fig. 13.23 – Rajasthan

Tourist Centres: Sikkim is famous for its lush green vegetation, forest, scenic valleys, majestic mountains, range of rich and magnificent cultural heritage and peace loving people who provide a safe haven for tourists.

Industry: The main industries of Sikkim include bamboo-craft, woodwork, spinning, carpet and rugs making, weaving, jewels, metal-work, silver-ware, and woodwork.

Power Projects: Tista and Rangit hydo-electric projects are important.

24. Tamil Nadu

Area: 1,30,058 sq km

Population: 72,138,958 (2011)

Capital: Chennai

Languages: Tamil

The state of Tamil Nadu is bounded by Andhra Pradesh and Karnataka in the north, Kerala in the west, while to the east and south lies the Bay of Bengal and the Indian Ocean (Fig. 13.25)

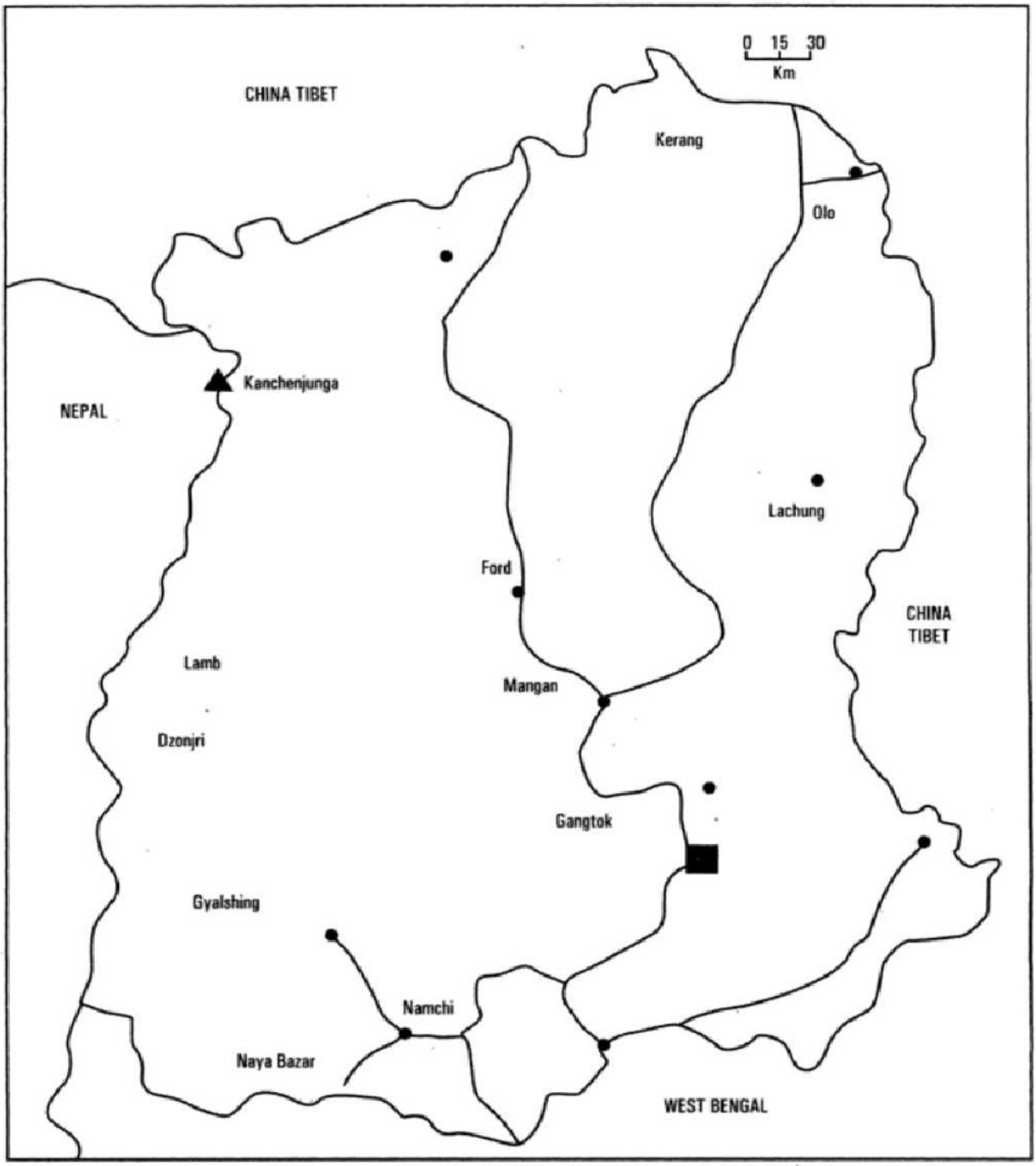

Fig. 12.25 – Sikkim

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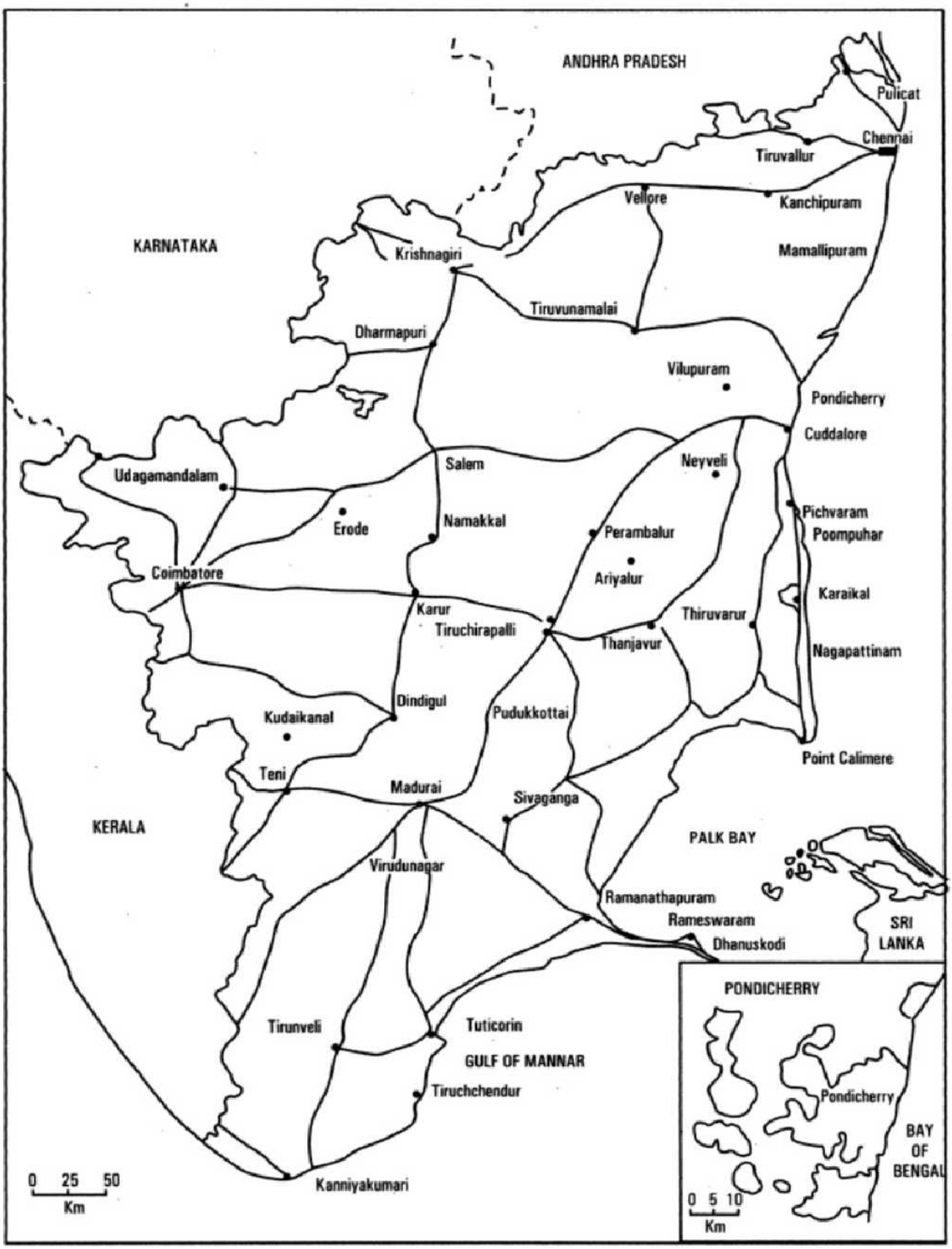

Fig. 12.26 – Tamil Nadu

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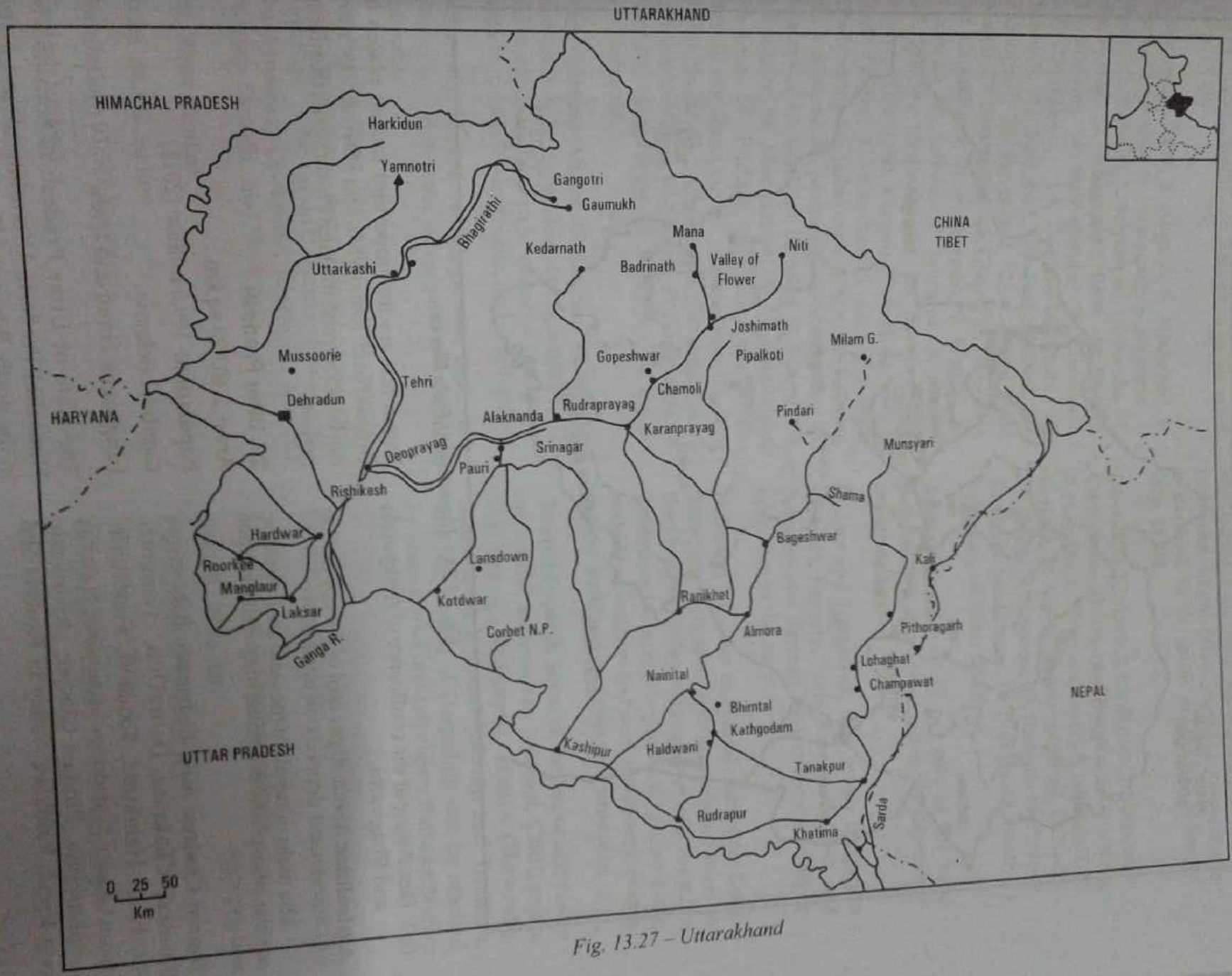

Fig. 13.27 – Uttarakhand

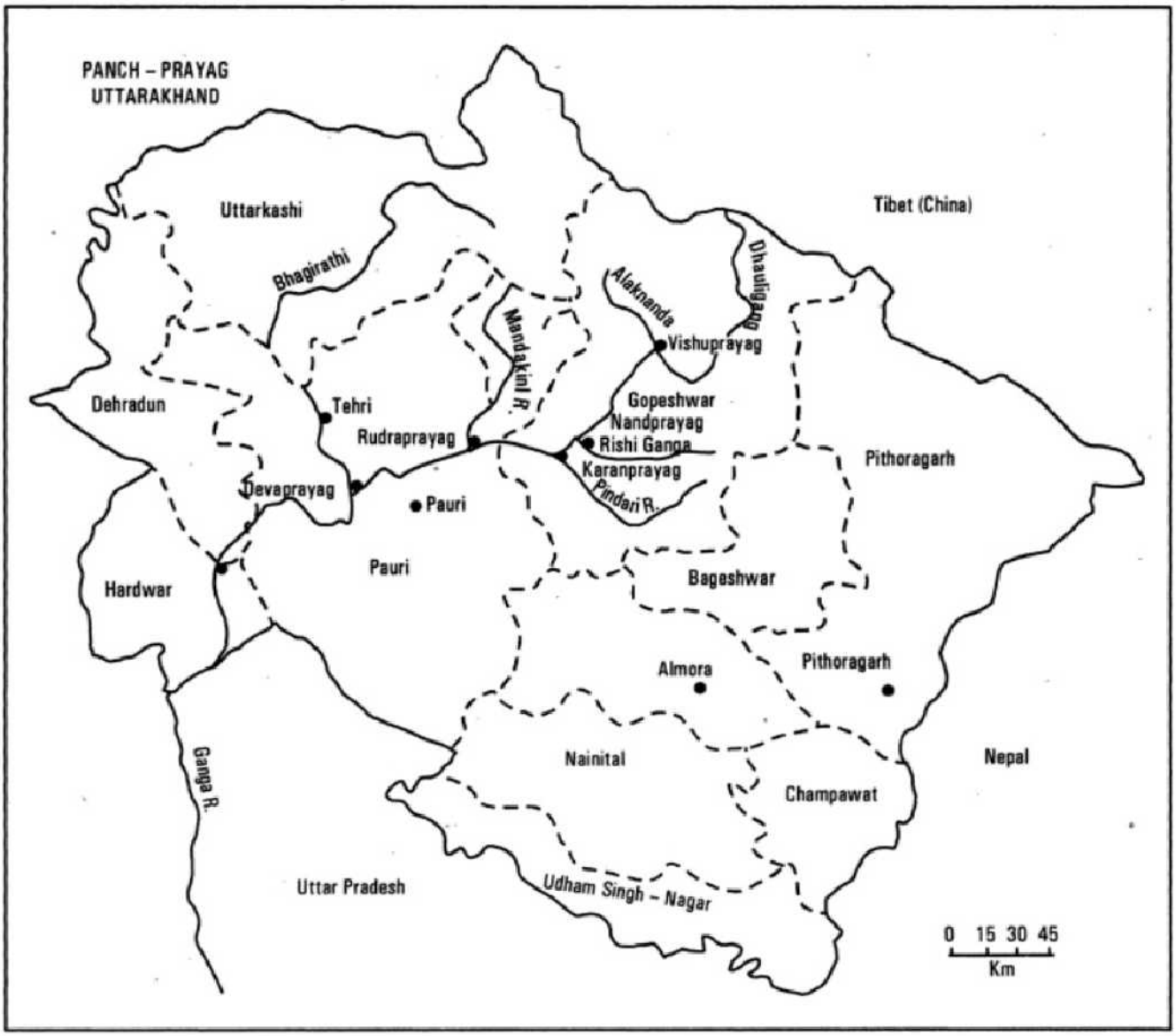

Fig. 12.29 – Uttarakhand Holy Places

(iv) *Rudra-Prayag* at the confluence of Alaknanda and Mandakni.

(iv) Dev-Prayag at the confluence of Alaknanda and Bhagirathi.

Agriculture: About 90 per cent of the population of Uttarakhand depends on agriculture.

The main minerals of the state are limestone, marble, phosphate, dolomite, magnesite, copper, and gypsum.

Tourist Centres: Auli, Badrinath, Bageshwar, Bhimtal, Chakrata, Dehra Dun, Gangotri, Hardwar, Hemkund, Kausani, Kedarnath, Milam Glacier, Lansdown, Mussoorie, Nainital, Nanakmattha, Pindari Glacier, Rishikesh, Roop Kund, Ranikhet, Valley of Flowers and Yamunotri are the important tourist places in Uttarakhand. Kailash Mt. and Mansarover Yatra can be performed through Phitoragarh (Kumaun region).

26. Uttar Pradesh

Area: 2,40,928 sq km

Population: 199.6 million (2011)

Capital: Lucknow

Languages: Hindi and Urdu

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The state of Uttar Pradesh is bounded by Himachal Pradesh, Uttarakhand and Nepal in the north, Bihar and Jharkhand in the east, Chhattisgarh and Madhya Pradesh in the south, and Haryana, Delhi and Rajasthan in the west **(Fig. 12.30)**.

Districts: 1. Agra, 2. Aligarh, 3. Allahabad, 4. Ambedkarnagar, 5. Azamgarh, 6. Baghpat, 7. Bahraich, 8. Ballia, 9. Balrampur, 10. Banda, 11. Barabanki, 12. Bareilly, 13. Basti, 14. Bijnore, 15. Budaun, 16. Bulandshahr, 17. Chandauli, 18. Chitrakoot, 19. Deoria, 20. Etah, 21. Etawah, 22. Faizabad, 23. Farrukhabad, 24. Fatehpur, 25. Firozabad, 26. Gautam Budh Nagar, 27. Ghaziabad, 28. Ghazipur, 29. Gonda, 30. Gorakhpur, 31. Hamirpur, 32. Hardoi, 33. Hathras, 34. Jalaun, 35. Jaunpur, 36. Jhansi, 37. Jyotiba Phule Nagar, 38. Kannauj, 39. Kanpur (City), 40. Kanpur (Dehat), 41. Kanshi Ram Nagar, 42. Kaushambi, 43. Kushinagar (Padrauna), 44. Lakhimpur-Kheri, 45. Lalitpur, 46. Lucknow, 47. Maharajganj, 48. Mahoba, 49. Mainpuri, 50. Mathura, 51. Mau, 52. Meerut, 53. Mirzapur, 54. Moradabad, 55. Muzaffarnagar, 56. Orai, 57. Pilibhit, 58. Pratapgarh, 59. Rai Bareli, 60. Rampur, 61. Saharanpur, 62. Sant Kabir Nagar, 63. Shahjahanpur, 64. Shravasti, 65. Siddharth Nagar, 66. Sitapur, 67. Sonbhadra, 68. Sant Ravi Das Nagar, 69. Sultanpur, 70. Unnao, 71. Varanasi.

Agriculture: About 67 per cent of the total population is dependent on agriculture. The main crops include rice, wheat, maize, pulses, millets, oilseeds, sugarcane, and small millets.

Minerals: Limestone, magnesite, coal, rock-phosphate, dolomite, silica, sand are the main minerals.

Tourist Centres: The main tourist centres of Uttar Pradesh are Agra, Allahabad, Ayodhya, Bareilly, Chitrakoot, Jhansi, Kaushambi, Kushinagar, Lucknow, Mathura, Meerut, Prayag, Sarnath, and Varanasi.

27. West Bengal

Area: 88,752, sq km

Population: 8,01,76,197 (2001)

Capital: Kolkata

Language: Bengali

The state of West Bengal is bounded by Sikkim and Bhutan in the north, Assam and Bangladesh in the east, Nepal, Bihar, Jharkhand and Odisha in the west. To the south lies the Bay of Bengal **(Fig. 12.31)**.

Districts: 1. Bankura, 2. Bardhman, 3. Birbhum, 4. Coochbehar, 5. Dakshin Dinajpur, 6. Darjeeling, 7. Hooghly, 8. Howrah (Haora), 9. Jalpaiguri, 10. Kolkata, 11. Malda, 12. Murshidabad, 13. Nadia, 14. North 24 Parganas, 15. Paschim Medinipur, 16. Purba Medinipur, 17. Purulia, 18. South 24 Parganas, 19. Uttar Dinajpur.

Agriculture: About 75 per cent of the total population is directly or indirectly dependent on agriculture.

Power and Irrigation: The major irrigation projects, namely, Tista Barrage Project and Subarnrekha Barrage Project are currently in operation in the state.

Industry: The main industrial centres are Kulti, Burnpur, Durgapur and numerous towns in the Hooghly Valley industrial region. The main industries include jute products, gunny bags, cotton textiles, iron and steel, machinery, electric goods, fertilizers and chemical products.

Tourist Centres: Some of the important places of tourist interest are Asansol, Chittranjan, Darjeeling, Durgapur, Haora (Howrah), Murshidabad, Shanti Niketan and Titagarh. The hill station of Darjeeling can be reached by train from New Jalpaiguri Railway Station **(Fig. 12.32)**.

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Fig. 12.30 – Uttar Pradesh

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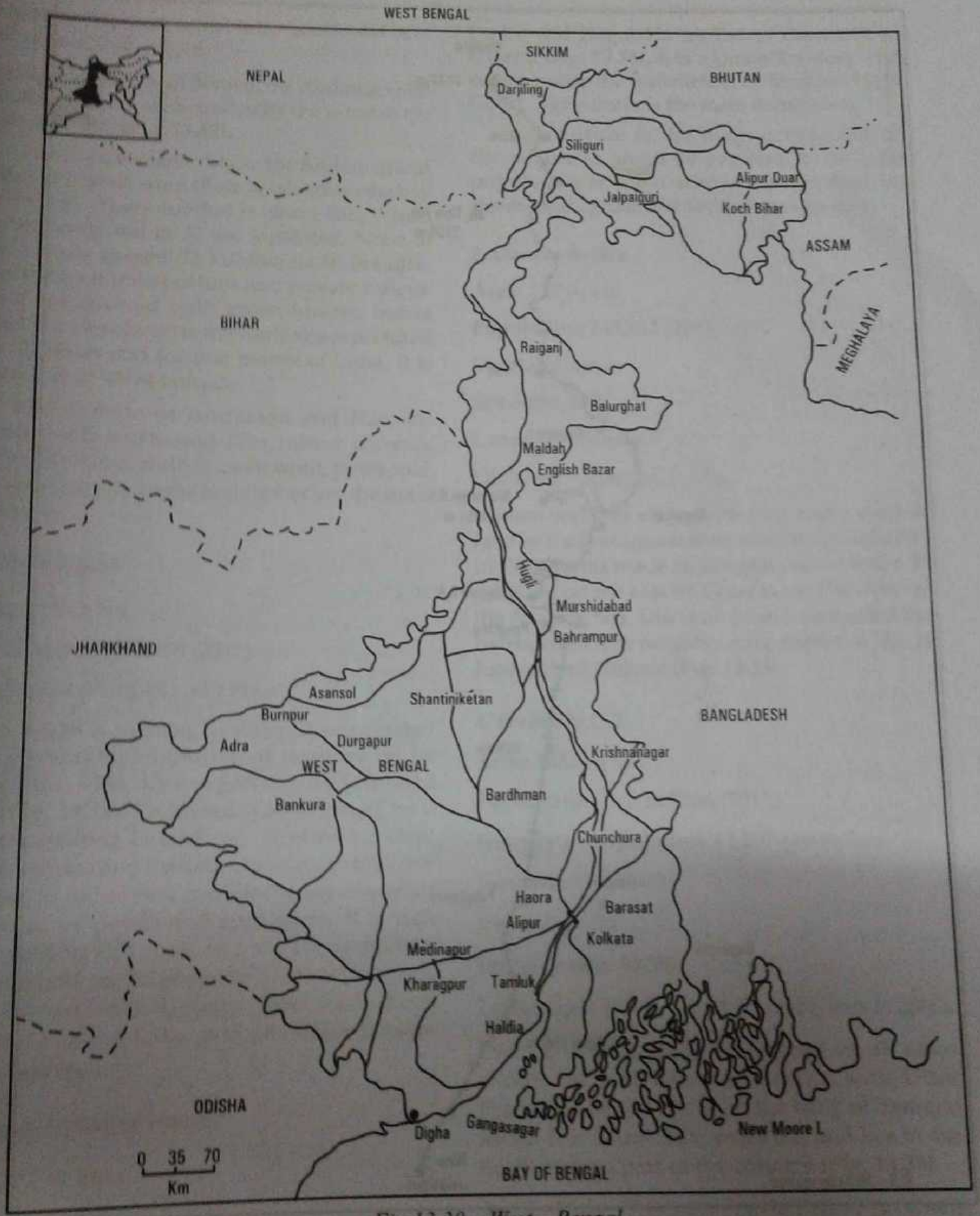

Fig.13.30 – West – Bengal

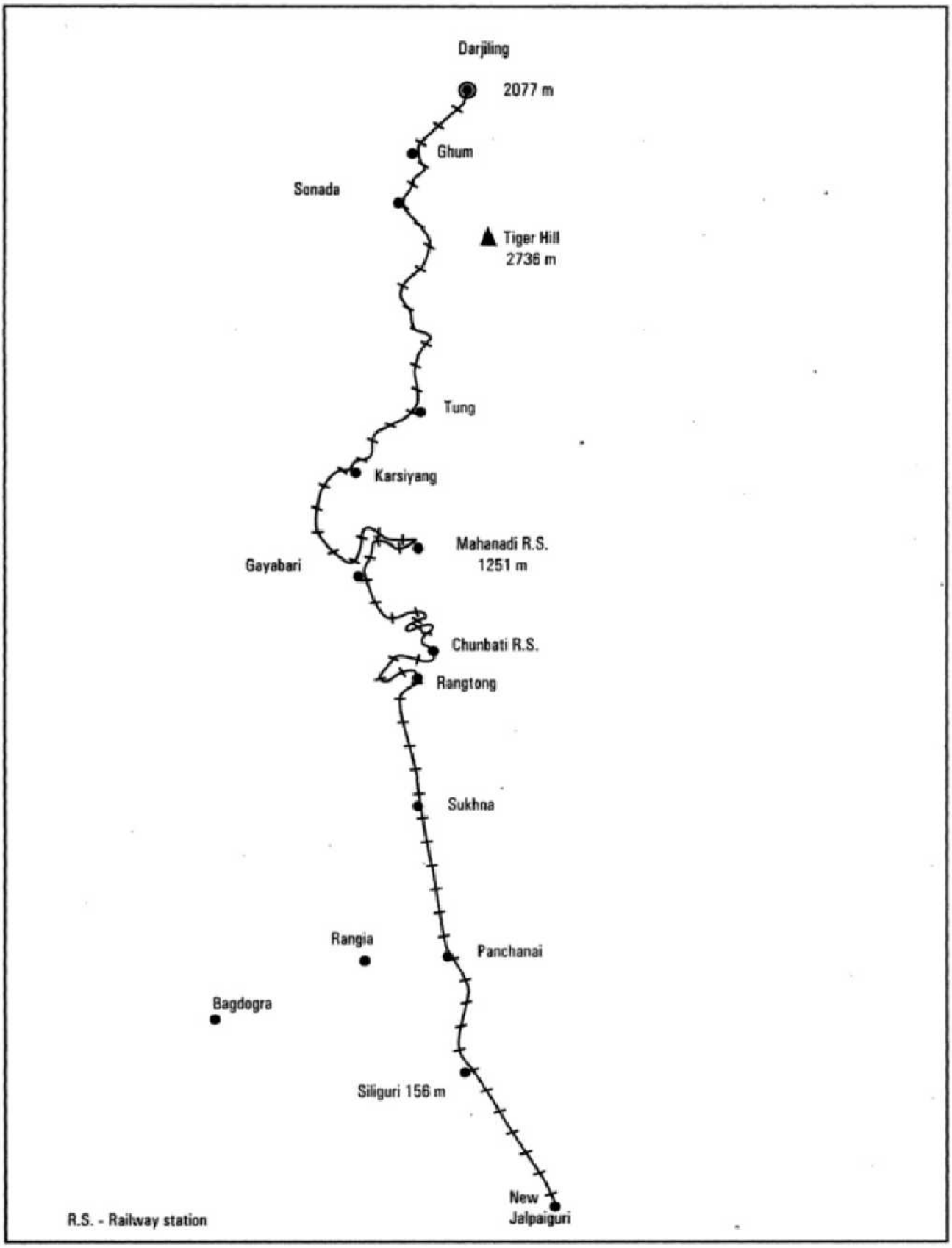

Fig. 12.32 – Darjeeling Himalayan Railway

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Timbers: The most valuable timbers found here are *padauk*, and *gurjan*.

Located in the Bay of Bengal, the Andaman and Nicobar Islands are bounded by the water of the Indian Ocean **(Fig. 13.32)**.

Having a volcanic origin, the Andaman and Nicobar Islands are a chain of islands in the Bay of Bengal. Their number is about 556. Which permanently out of 37 are inhabited. None of the islands exceed 32 kilometers in breadth. There are a number of hills and narrow valleys. They are covered with green forests. Indira Point (La Henching) is the southern-most tip of the Nicobars and for that matter of India. It is located at 6° 45/ N latitude.

The climate of Andaman and Nicobar Islands is hot and humid. Rice, rubber, coconut, coffee, cinchona, chillies, cashewnut, pineapple, mango, papaya, herbs and timber are the main products.

2. Chandigarh

Area: 114 sq km

Population: 1,054,686 (2011)

Languages: Punjabi and Hindi

Chandigarh is a Union Territory. It was created into a centrally administered territory on Ist November, 1966. Chandigarh is a well planned city **(Fig. 13.33)**. Its layout was prepared by a French architect, Le Corbusier. It is the capital of both Haryana and Punjab. Chandigarh has over 3000 small industries, manufacturing a number of consumer goods and appliances. It is well connected by rail, road, and air. The important tourist places are Bougainville, Capital Complex, Museum and Art Gallery, Deer Park, Rock Garden, Sukhna Lake, and Dr. Zakir Husain Rose Garden.

3. Dadra & Nagar Haveli

Area: 491 sq km

Population: 342,853 (2011)

Capital: Silvassa

Languages: Gujarati and Hindi

Dadra and Nagar Haveli lies to the south of Gujarat **(Fig. 13.34)**. It is a Union Territory and comes under the jurisdiction of Mumbai High Court. Agriculture is the main occupation.

Agriculture is the main occupation of the people as about 80 per cent of the total population is tribal who are dependent on forests and agriculture for their sustenance.

3. Daman & Diu

Area: 112 sq km

Population: 242,911 (2011)

Capital: Daman

Sex-ratio: 618

Language: Gujarati

Districts: 1. Daman, 2. Diu.

Daman and Diu along with Goa was a colony held by the Portuguese even after Independence. In 1961, it was made an integral part of India. It is bound on the east by Gujarat, on the west by the Arabian Sea. Diu is an island connected by two bridges. The neighbouring district of Diu is Junagarh of Gujarat **(Fig. 13.35)**.

4. Delhi, N.C.T.

Area: 1483 sq km

Population: 16.8 million (2011)

Density of population: 11,297 per sq km

Sex-ratio: 866/1000

Capital: Delhi

Liferacy rate: 86.3%

Languages: Hindi, Urdu, Punjabi, and English

Delhi is surrounded by Haryana on all sides except the east where it borders with Uttar Pradesh. The old city is on the bank of Yamuna River. It is about 3000 years old and lies in the north-central part of the country **(Fig. 13.36)**.

Agriculture: The main agricultural products include wheat, *bajra*, gram, maize, oilseeds, vegetables, flowers, dairy, poultry and orchards.

Power: The power demand of Delhi is much more than the power being generated at Rajghat Power House, Indraprastha Station, and gas-turbine including Badarpur Thermal Power Stations. The remaining power is being drawn from the Northern Grid.

Industry: The main industries of Delhi include steel casting, drugs and pharmaceuticals, chemicals, paints, varnishes, television sets, radios, transistors, electrical appliances, scientific instruments, readymade-garments, and vegetable-oil. The cottage industries include ivory work, gold and silver embroidery, brass and copper-wares.

Tourist Centres: Qutab Minar, Humayun's Tomb, Jama-Masjid, Lal-Qila (Red Fort), Jantar Mantar, Gandhi Samadhi (Raj Ghat), Gurudwara Sisganj, Shanti Vana, Vijai Ghat. Rashtrapati Bhavan, Mughal gardens,(open for public in the month of February and March), Parliamanet House, Central Secretariat, Birla Mandir, India Gate, Teen Murti Bhavan and Lotus Temple.

6. Lakshadweep

Area: 32 sq km

Population: 64,429 (2011)

Capital: Kavaratti

Language: Malayalam

Lakshadweep, a group of islands consist of 12 atolls. There are 36 reef-islands, out of which only 11 islands are inhabited. These islands lie about 280 to 480 km off the Kerala coast in the Arabian Sea **(Fig. 13.37)**. Fishing, coir-matting, copra-processing, fish preservation and cultivation of coconuts are the main occupations. Tourism is a good source of income to the people. Its capital, Kavaratti is only about one to two metres above the sea level.

Coconut and vegetables are the main crops. The coconuts of Lakshdweep are the highest oil content nuts in the world (72 per cent). Tourism is developing into an important industry. The important tourist places are Agatti, Bangaram, Kalpeni, Kadmat, and Minicoy, etc.

7. Puducherry

Area: 479 sq km

Population: 1,244,464 (2011)

Capital: Karaikal

Sex-ratio: 1038/1000

Languages: Tamil, Telugu, Malyalam, French

Districts: 1. Karaikal, 2. Mahe, 3.Puducherry, 4. Yanam

Formerly known as Pondicherry, it was under the French rule for 138 years and merged with the Indian Union on Ist November, 1954. It is bounded on the east by the Bay of Bengal and on the three sides by Tamil Nadu. About 150 km south of Puducherry on the east coast lies Karaikal. Mahe is situated on the Malabar coast on the Western Ghats surrounded by Kerala. Yanam is situated adjoining the East Godavari District of Andhra Pradesh.

Agriculture: Ninety per cent of the Poducherry's cultivated area is irrigated. Rice is the staple food crop. Other crops include *ragi*, bajra, pulses, sugarcane, groundnut, cotton and root crops.

Industry: Cotton textile, sugar, paper, spirits, beer, soap, and medicines are the main industries.

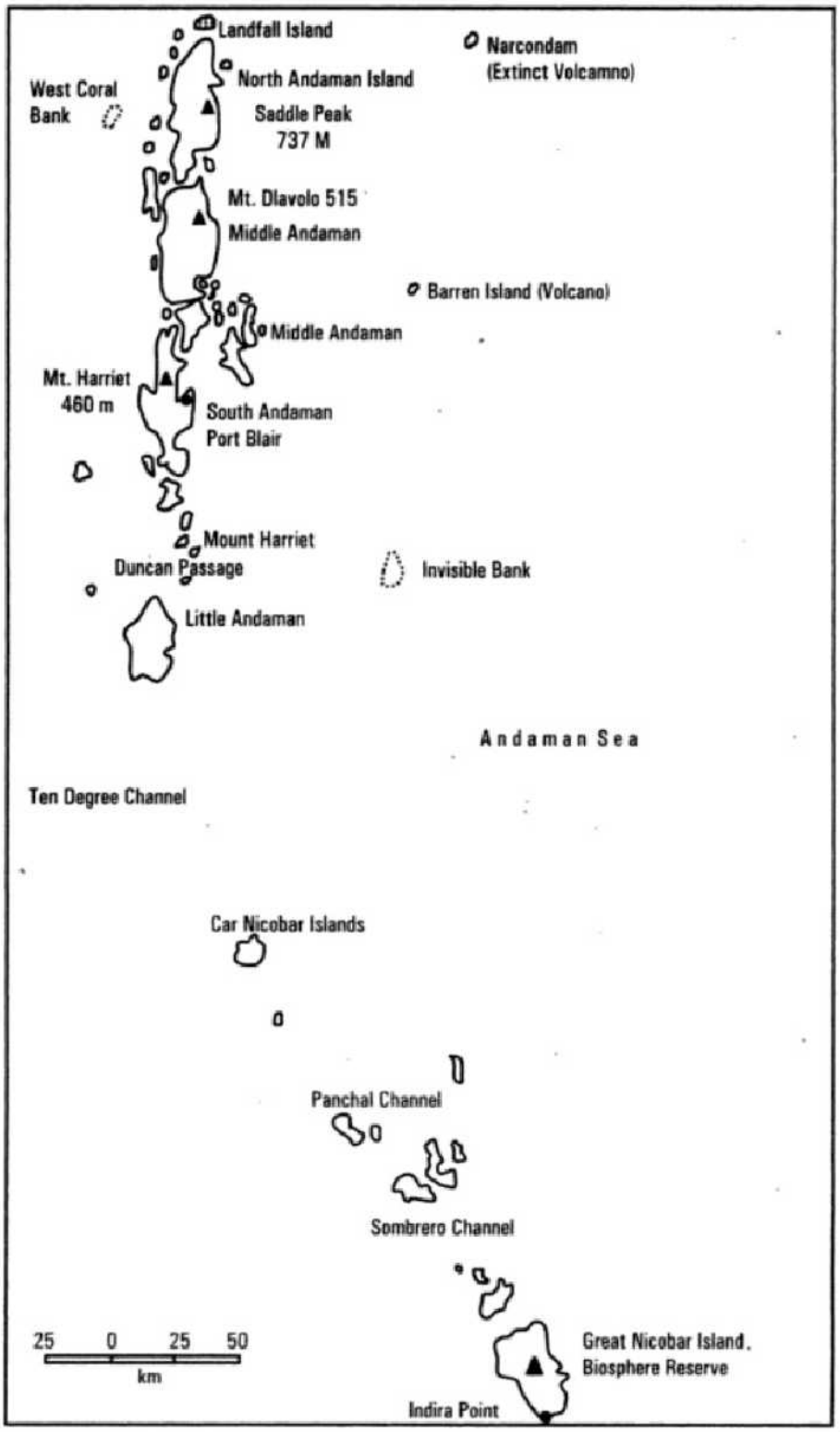

Fig. 12.33 – Andaman and Nicobar Islands

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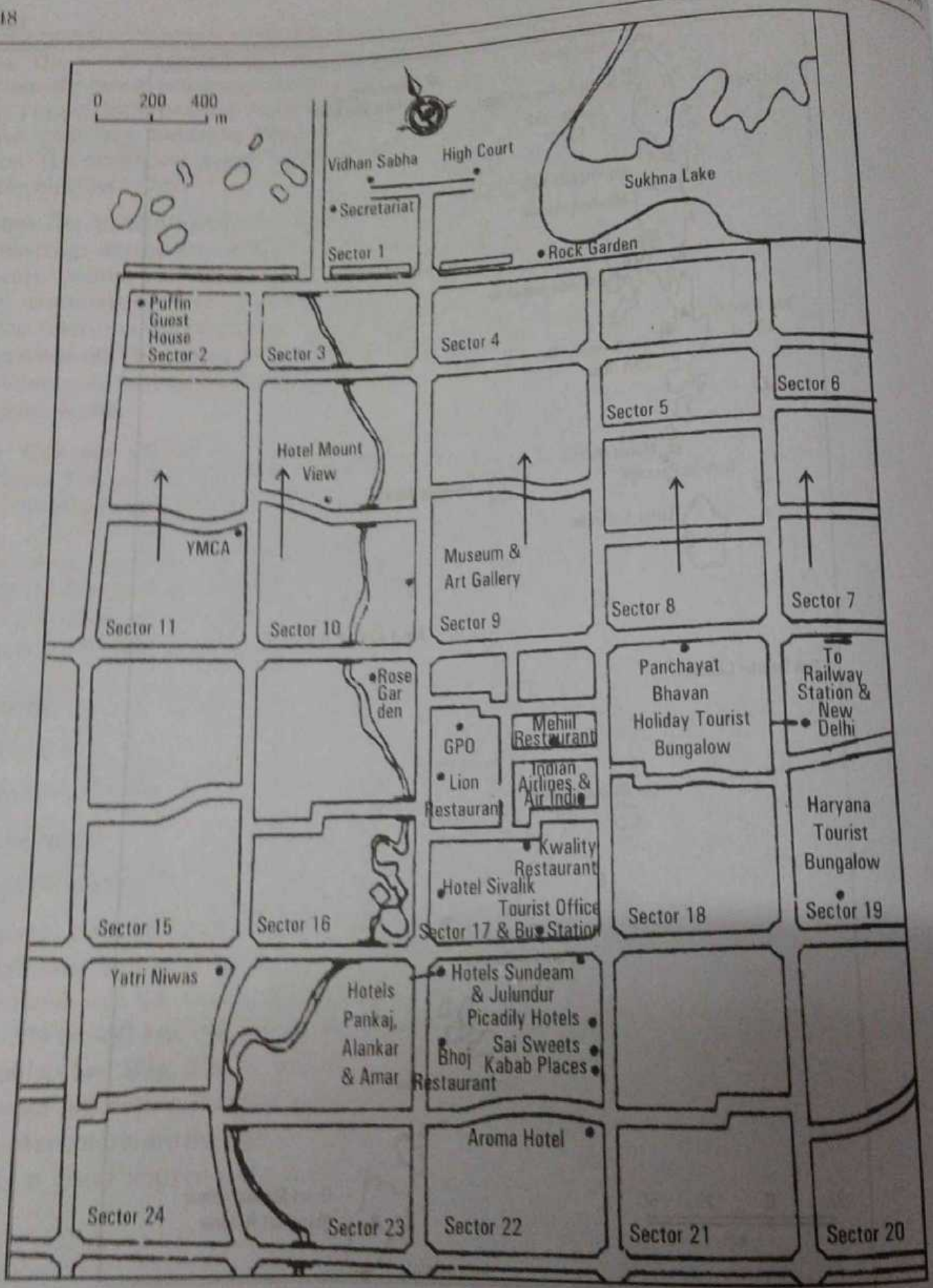

Fig. 13.33 – Chandigarh

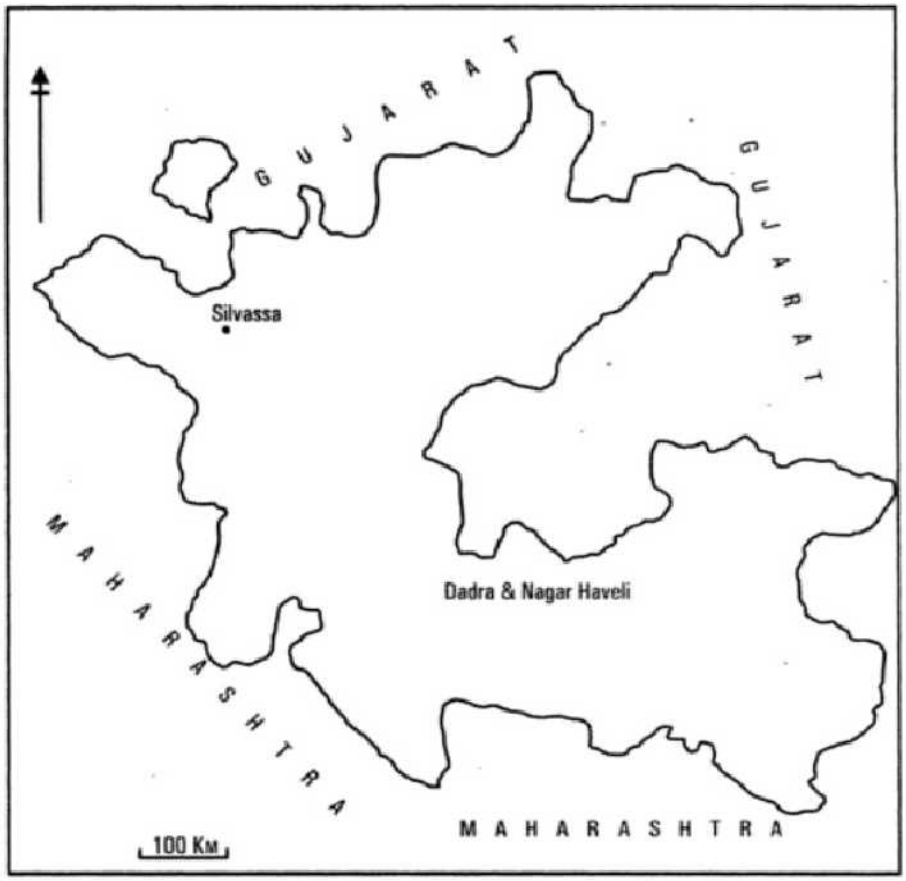

Fig. 12.35 – Dadra & Nagar Haveli

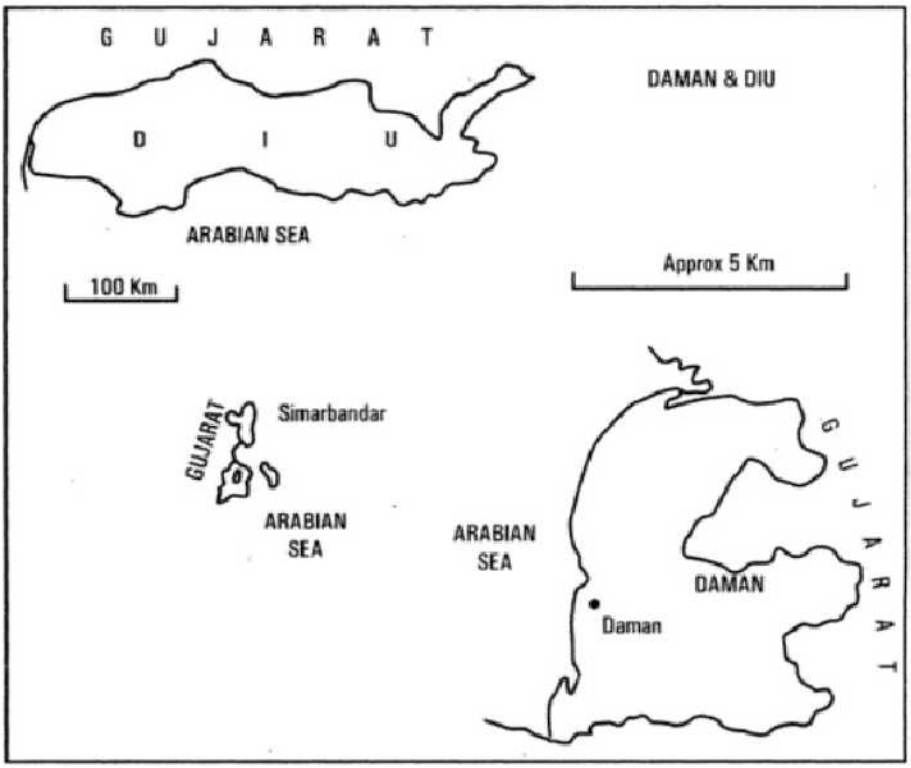

Fig. 12.36 – Daman & Diu

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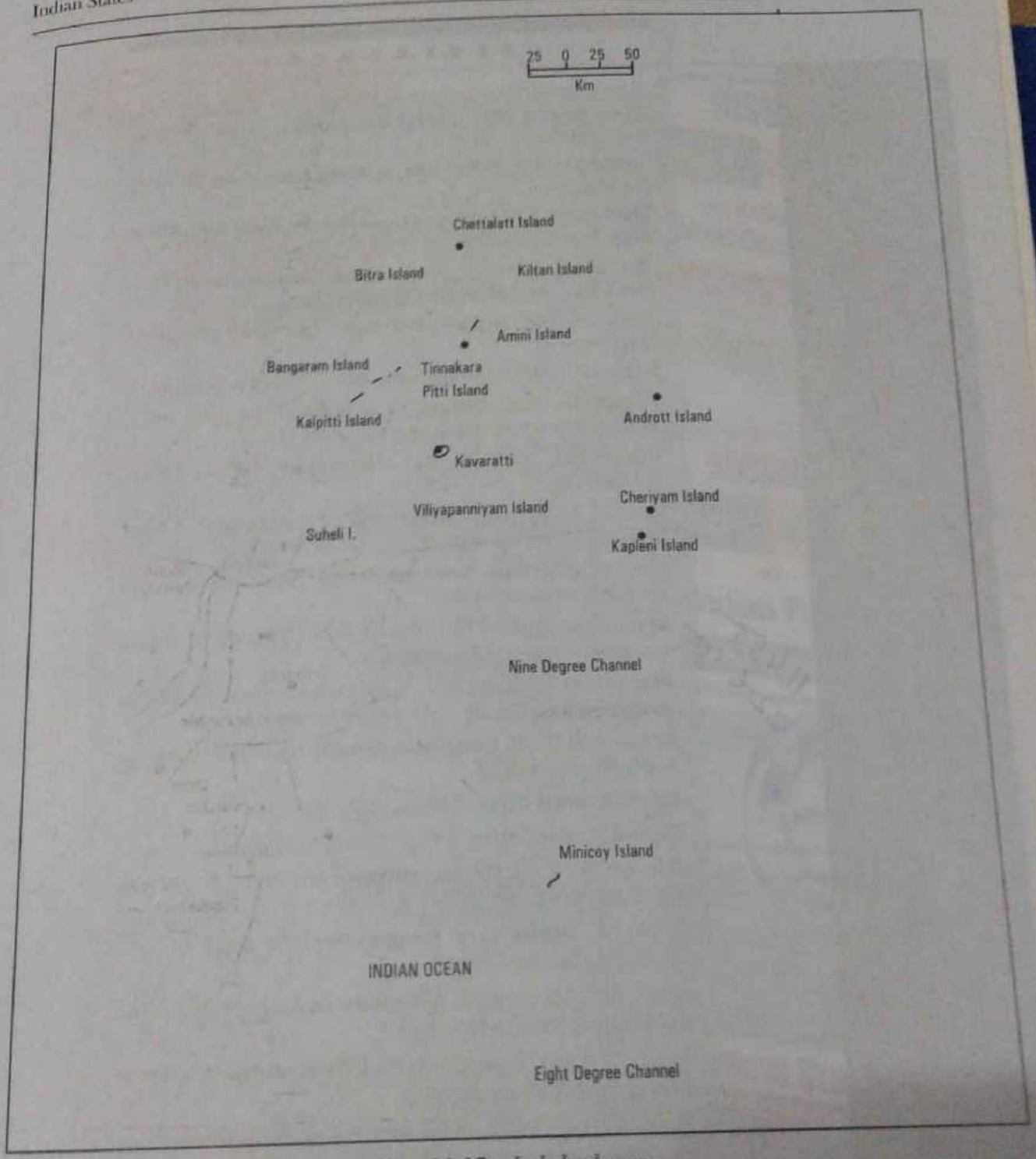

Fig. 13.37 – Lakshadweep

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Majid Husain is former Professor and Head, Department of Geography, Jamia Millia Islamia, New Delhi and is a prolific writer on geographical topics. He has been fellow and President of the Indian National Cartography Association and vice president of the International Association of Landscape Ecology.

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